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ARTICLES

SOME GROWTH-PROMOTING SUBSTANCES IN ANIMAL FEEDING

M. Whalley Taylor

Deputy Agricultural Attaché, Washington

Only a few years ago the non-ruminant nutrition specialist believed that the principles of pig and poultry feeding were well understood. However, certain American research workers, experimenting with rather crude materials (indeed, some were very crude, for they included cow manure), described a factor which stimulated growth in chickens. This substance was later called the "Animal Protein Factor" because it exerted a major effect on vegetable protein diets. In fact, young pigs and chickens grew almost as rapidly on vegetable protein rations, plus the A.P.F., as they did when they received feeds containing proteins of animal origin. Contrary to the earlier teaching, it was established that the special value of animal proteins in nutrition was not due exclusively to their amino-acid composition, but was also a result of their being associated with growth-promoting substance(s).

In 1948, it was established that the important constituent of the A.P.F. was vitamin B_{12}. This anti-pernicious anaemia vitamin is now known to contain both cobalt and phosphorus and to occur in small quantities in animal products, gut contents, and other materials subject to bacterial fermentation.

The next stage was the manufacture of A.P.F. from antibiotic (aureomycin) sludge. When this material was fed to chickens an increase in growth rates occurred in excess of that caused by vitamin B_{12} alone. Stokstad and Jukes [1] demonstrated that this extra stimulation was due to the presence of the antibiotic. As a result of these findings, a very large number of investigations have been carried out on the general subject of vitamin B_{12}-antibiotic supplements in animal feeding. The chief antibiotics which have been used are: penicillin, aureomycin, terramycin, and bacitracin.

Although it is difficult to summarize the mass of data adequately in a short article, certain broad conclusions may be drawn. In all animals the effects of vitamin B_{12}-antibiotic feeding are most pronounced in young stock. In poultry the growth rates and efficiency of feed utilization reach their maxima at six to eight weeks of age; but they are still evident when broilers are sold at nine to twelve weeks, or turkeys at twenty-two to twenty-four weeks old. The antibiotic may be removed from the diet of turkeys at eight to twelve weeks with a good expectation that the early advantage in growth will be maintained. However, because the response to antibiotics

is very much conditioned by environment, it is not a good practice to remove the antibiotic from the diet just when stock is removed from one environment to another; for example, when turkeys are changed from brooding to range quarters.

When a vitamin B_{12}-antibiotic supplement is included in the starting rations of chickens, turkeys and pigs, increases in liveweight gains of up to 30 per cent occur, although the average gain is probably about 10 per cent. It is interesting to note that the increase in growth rate of turkeys which results from feeding these supplements is greater than that which occurs in chicks, and there is some information to show that female poults make faster relative growth than their brothers in these circumstances. Ducks, on the other hand, show little if any response to antibiotic feeding so far as liveweight gains are concerned.

Antibiotics, in many environments, bring about significant economies in the conversion of feed to flesh. With adequate rations, good stock and sound management, 3 lb. meal per lb. liveweight gain can be achieved with pigs; and with poultry 1 lb. liveweight gain for 2.75 lb. of meal (up to ten weeks) is not uncommon. When an antibiotic is used in the starter diet of replacement chicks, the improvement in growth rates and feed efficiency is maintained until they are about twenty-two weeks old. However, at this age the difference in feed efficiency just about balances the extra cost of the antibiotic, and the difference in weight disappears quickly after the onset of egg production. The feeding of antibiotics appears to have no effect on early rate of laying nor on egg weight during the first month of production. Antibiotics also curb many forms of diarrhoea which frequently occur in calves and piglets, but they have no effect on the ailment in chicks—probably because diarrhoea in chickens is usually not of bacterial origin.

Catron and his colleagues at Ames, Iowa [2] have obtained spectacular results with runt pigs which had received vitamin B_{12} and antibiotic supplements. For example, pigs which averaged 21 lb. at seventy-two days, made average daily gains of 1.37 lb. during the next seventy days, and gained 1 lb. for each 2.65 lb. of meal consumed. The ration contained twenty milligrams of aureomycin and ten micrograms of vitamin B_{12} per lb. of feed. Similar pigs in the control pens which received an adequate ration (apart from vitamin B_{12} and antibiotics), gained at the rate of 0.86 lb. per day and required 3.08 lb. of feed for each lb. of liveweight increase.

Though the results from Iowa State College and several other experimental stations indicate that antibiotics improve the efficiency of food utilization in the pig, there has been, during recent months, an increasing amount of experimental evidence [3, 4] to the effect that antibiotics do not enable growing pigs to make more efficient use of the food. Until more evidence is available, it is not advisable to say categorically that these substances, under all farm conditions, effect a saving in food.

These supplements appear to exert a protein-sparing effect in the diet of pigs, and though the experimental evidence is conflicting, the balance is in favour of antibiotics also having a sparing effect on proteins in chick nutrition.

How do Antibiotics Work?

The mode of action of vitamin B_{12} is thought to be similar to that of other vitamins, namely, in the direct stimulation of the recipient animal, probably through the enzyme system which assists in the breakdown of proteins and the metabolism of nitrogen compounds. On the other hand, it is believed that the antibiotics have a pronounced effect on the intestinal flora. The result of this may be the suppression of entero-toxin-producing clostridia; a reduction in the numbers of intestinal micro-organisms, thus lowering the competition for nutrients; or a stimulation of vitamin synthesis by the intestinal microflora.

The work carried out at the National Institute for Research in Dairying and the Glaxo Laboratories [5], where it was shown that the growth-stimulating effect of an antibiotic could be duplicated by keeping chickens in isolation in new quarters, has been repeated in the United States. Bird and his co-workers [6] confirmed the results at Beltsville with the interesting difference that the chicks without the antibiotic in new quarters grew even faster than those with the antibiotic in old quarters. In other experiments at Beltsville, four-week-old chicks were removed from new, clean quarters to old, contaminated equipment. When chicks which had been on an antibiotic diet were moved and simultaneously deprived of the antibiotic, a marked interruption of growth was noticeable. If they were moved but continued to receive the antibiotic, no check in growth occurred. Chicks which had received the antibiotic from hatching time and were kept in old, contaminated quarters, showed no abrupt interruption in growth rate when the antibiotic was removed from the feed. This evidence leads to the conclusion that the mode of action of antibiotics is by way of their effect on intestinal micro-organisms. However, it has been reported from the Texas Experimental Station [7] that injection of autoclaved penicillin increases growth rate without affecting the intestinal bacteria and, therefore, the effect of these compounds on growth may well be due to several causes.

Feeding and Long-term Effects of Vitamin B_{12} and Antibiotics

Adequate dosage of vitamin B_{12} for growing chickens is in the region of seven micrograms per lb. of feed in an all-vegetable diet. With poultry, a deficiency of vitamin B_{12} in the breeders' diet will result in reduced hatchability. Also, if the diet of the breeding stock is inadequately supplied with the vitamin, it is almost impossible to improve the viability or feathering of those chicks which hatch by including it in the chick ration. It therefore appears that the best

source of this vitamin to the chick is that which is passed on from the dam through the egg. Providing the breeders' ration contains 6 per cent good fishmeal there is no need to add vitamin B_{12}, but should the fishmeal be of poor quality or present in smaller quantities, two to four micrograms of vitamin B_{12} per lb. should be added to the breeders' mash.

The dosage varies for each type of antibiotic used. For instance, one microgram of procaine penicillin, or four micrograms of aureomycin, terramycin, or bacitracin, are recommended per lb. of feed; as distinct from vitamin B_{12}, antibiotics have no effect on hatchability and do not appear to be carried over in measurable quantity in the foetus or egg. Of the antibiotics used, probably procaine penicillin—a relatively insoluble form—has proved as effective as any for non-ruminants.

In certain intensive broiler areas where disease—especially air-sac infection—has lately been troublesome, very high levels (100 grammes per ton) of aureomycin or terramycin have been added to the mashes. This has so far caused no obvious ill-effects and, though chicks infected artificially in the laboratory have failed to respond to the antibiotic therapy, the high dosage does appear to have a beneficial effect when used in commercial broiler plants.

In view of the interest in the long-term effects of feeding antibiotics, it is worth reviewing the American experience in this field. Antibiotics have now been fed to pigs and poultry for four years—admittedly quite inadvertently during the first year—without noticeable deleterious effects. In spite of these substances being recommended exclusively for young stock, some over-enthusiastic farmers have fed them to adult pigs and laying hens. The extent to which they are used for young pigs and poultry is really remarkable, for it is estimated that in mixed poultry feeds (and very few poultry-farmers mix their own ration), 90-100 per cent of broiler rations, 50-55 per cent of growers' mash, 25-30 per cent of layers' and breeders' mash, 75-80 per cent of turkey mashes, contain vitamin B_{12}-antibiotic supplements. Considering broiler production alone, the use of antibiotics is estimated to have saved forty million dollars worth of feed during the last year. So far as pigs are concerned, it is more difficult to estimate the usage of these supplements because many farmers normally compound their own feed mixture. Nevertheless, it can be said that appreciable quantities are sold for this purpose. The present annual value of vitamin B_{12}-antibiotic supplements sold for animal feeding is estimated at between twenty-five and thirty million dollars.

Some preliminary work carried out at the University of Alberta and at Purdue University, Indiana, suggests that the quality of pig meat may be slightly impaired if an antibiotic is fed up to slaughter date. It may, therefore, be advisable to withdraw these substances from the rations when the pigs reach 140 lb. live weight. There is also a report from a laboratory where Rickettsia were being grown in

eggs, to the effect that the organisms would not develop in eggs from birds which had received antibiotics in the feed. This finding is probably of little practical importance because farmers are unlikely to feed antibiotics to adult stock. Though the massive doses of antibiotics currently being used in some broiler areas have shown no side-effects, it will be interesting to note if any long-term effects come to light.

Use of Phenylarsonic Acids

Derivatives of phenylarsonic acid were first used in poultry mashes as anti-parasitic drugs when it was noted that they had a growth-stimulating effect. Later research demonstrated that they also improved feathering and intensified pigmentation of the shanks, comb, and wattles. Their effect on appearance is consistent, but their effect on growth promotion, when added to rations containing an antibiotic, is inconsistent for both pigs and poultry. Generally speaking, however, extra growth over and above that caused by an antibiotic is noticeable.

At present, two phenylarsonic acids are being added to commercial broiler and turkey rations. They are, 3-nitro-4-hydroxyphenyl-arsonic acid and arsanilic acid; the latter is used both as the free acid and as the sodium salt. The dosage of the 3-nitro compound is 0.005 per cent of the diet, and of sodium arsanilite about 0.009 per cent. Because the chief effect of these compounds is to enhance the appearance and promote relatively early growth, they are used exclusively in broiler and turkey rations, and there is no reason to include them in the diets of replacement stock or laying birds. The arsenicals are toxic to poultry and, in fact, if the 3-nitro compound is fed at the 0.02 per cent level, it will prove fatal to chickens. This necessitates very careful handling on the part of the compounder but, because there appears to be a negligible build-up in the pig or poultry tissues, there is no danger to the person eating the carcass. The vast majority of the arsenic in the tissues is excreted within three days of the removal of the drug from the diet.

As opposed to antibiotics, the arsenicals do not give any growth response until after chickens are four weeks old, and they appear to elicit a maximum response from birds kept under extremely sanitary conditions. Their mode of action, therefore, probably differs from that of the antibiotics, but just how they function is not known. They are much more toxic to waterfowl than to poultry, and although effective for pigs, they have not so far been incorporated in commercial pig feeds.

Confused Results with Surfactants

Surfactants or surface-active agents have excited interest amongst research workers since the laboratories of the National Distillers Incorporated [8] first reported that they acted as growth stimulants. Of the many substances that have been tested on chicks by these

laboratories, lauryl ethylene oxide condensate, sodium ethylene diamine tetra-acetic acid, quaternary ammonium compounds and sodium alkyl aryl sulphonate have proved the most successful. These materials were fed at the rate of between 1 and 2 per cent and, when they produced growth stimulation, it was more noticeable on a vegetable than on an animal protein diet. But, in most cases, vitamin B_{12} was more effective and just as cheap. The feeding tests were run for twelve weeks and the surfactants gave no response until the chicks were at least six weeks old. The same laboratory also reported some tests with common detergents or synthetic soaps, when inconsistent but, on the whole, positive results were obtained.

Other research establishments have carried out experiments along similar lines. The Illinois Agricultural Experiment Station [9] failed to obtain any increase in growth when using six surface-acting agents during the first twenty-eight days. Two of the surfactants actually depressed growth and there was a high incidence of perosis amongst the chicks.

The evidence regarding surfactants is, to date, so confused that it is not possible to say more than that their growth-stimulating effect is an important subject for further research and, at present, they have no practical application.

Some Unidentified Growth Factors

For several years, evidence has been accumulating which indicates that certain feedingstuffs such as fishmeal, fish solubles, liver, dried milk, dried whey, dried distillers' solubles, and dried brewers' yeast, contain unidentified growth factors which are required by chicks and poults. Within the past year, reports from the University of Maryland [10] and Washington State College [11] suggest that one of these factors is present in dried whey and another is present in liver fraction, fish solubles and yeast. Lillie and his colleagues at Beltsville [12] have found an unknown growth factor in fishmeals, meatmeals, and fish solubles, which is not supplied by a diet containing maize and soya bean meal, plus an antibiotic, and the known minerals and vitamins, including B_{12}. This factor has been concentrated, and even when a crude concentrate is added to the diet at the rate of 0.05 per cent, there is a growth response. As the growth-stimulating effect is destroyed by ashing, and very small quantities effect a response, it may well prove to be a vitamin. Another interesting fact is that this material appears to be much more effective when fed to chicks specially bred for rapid growth.

Still another unknown growth-promoting factor is apparently present in grass juice, but is not found in dried grassmeal. It was described by Scott [13] as it affected turkeys, and Kohler and Graham [14] found it effective for chicks. Slinger [15] confirmed the presence of this factor in forage juices and found that under the influence of penicillin the substance was either synthesized in the

intestinal tract of the turkey, or rendered more available to the poult. There is certainly one, and probably more than one, unknown growth-promoting factor in fishmeal and similar substances, and probably still another in grass juice. They are required to obtain maximum growth even in the presence of an antibiotic, but the factors present serve to lower the percentage response to the antibiotic. The antibiotic may cause some inadequate synthesis of the factors, or only one factor may be synthesized or "spared" by the antibiotic.

Effects of Antibiotics on Calves

The emphasis in this article has been on poultry and pigs. However, some work has been carried out with ruminants. Of the antibiotics, aureomycin has been used most extensively, though terramycin has also been fed. Experimental evidence suggests that an increase in weight of 10-30 per cent often occurs in calves when an antibiotic is fed during the first sixteen weeks of life; the major part of this increase can be attributed to condition, though there is some evidence that skeletal development is also stimulated. Another effect, as already mentioned, is to reduce the incidence of scours, and this, in itself, no doubt contributes to quicker growth, although calves receiving antibiotics in the feed do have bigger appetites. Although the data are in some cases conflicting, the balance of evidence suggests that food is better utilized by the young ruminant when antibiotics are fed, and that the greatest response occurs in thrifty calves of the smaller breeds. There is reason to believe that the continuous feeding of antibiotics to calves has no harmful effects on the development or function of the rumen, and that older calves which receive hay and grain also respond to antibiotics. On the other hand, there is no evidence about the long-term effects of feeding antibiotics either continuously or during calfhood, on milk production, reproduction, or in the treatment of disease. However, the stimulus given to growth by these substances during early life does not seem to retard growth at a later date when their feeding is discontinued. The quantities of antibiotics included in the rations have varied widely, but the indications are that for aureomycin, between ten and thirty milligrams daily per 100 lb. live weight of calf is probably the optimum level, and this would cost about $\frac{1}{2}$d. per day at present prices.

No attempt has been made to cover the whole field of growth-promoting substances, for no mention of hormones has been made, nor has it been possible to discuss the recent work conducted in the mid-Western States on the feeding of roughages (including corn cobs) with the addition of such substances as molasses, urea, and cobalt to beef cattle. Nevertheless, it is quite obvious that a whole new field of possibilities in the realm of animal feeding has been opened. So far, only the fringes of this field have been touched.

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THE EFFECTS OF CLIMATE ON CATTLE AND THEIR PRODUCTIVITY

J. D. Findlay

The Hannah Dairy Research Institute, Kirkhill, Ayr

The productivity of cattle is affected by their climatic environment both directly and indirectly. Indirectly, since temperature, humidity, air movement, solar radiation, barometric pressure and rainfall affect crops, and hence the nutrition of cattle. Directly, because changes in these components of climate affect the temperature-regulation system of cattle by stimulating their nervous and endocrine systems, so that they may lose or conserve heat as the need arises. In extremes of climate the direct effects of climate will naturally be very great. It is only within recent years, however, that the interest of animal physiologists has been focused upon the direct effects of climate on farm animals, and this interest has principally centred on cattle.

The reasons for this interest are threefold. Firstly, the mechanisms employed by the bovine to regulate its body temperature are imperfectly understood, and fundamental investigations in this branch of knowledge are opening up new vistas in the application of biophysics to agricultural problems. Secondly, since much of the world's food supply must, in the future, come from the tropics, it is vitally important to determine how the productivity of cattle is affected by extreme weather conditions (particularly by heat, humidity and radiation), and how different breeds of cattle react to such conditions, so that a physiological basis for the selection of cattle for high productivity in the tropics may be established. Thirdly, it is important for farmers in those parts of the world where cattle are kept indoors for a large part of the year, to know the conditions inside their farm buildings which will give optimum productivity, so that the design of byres may be based on sound physiological principles of ventilation.

When the environmental temperature is lower than the body temperature of an animal, the animal must conserve heat by increasing its thermal insulation by such means as reducing the blood supply to its skin, reducing its surface and respiratory tract vaporization rate, and reducing its surface area by huddling. If these means are insufficient to prevent its deep body temperature from falling, it must then increase its heat production by shivering, and so increase the heat formed in its muscles ; or it must eat more food. If there is insufficient food for cattle they must reduce their productivity either by reducing their yield of milk, or by reducing the amount of protein and fat they lay down in their tissues.

For all mammals which are homeotherms there exists a zone of temperature in which they can maintain their normal body temperature without appreciably altering their heat production, and in which heat balance is maintained by physical means such as evaporation from body surfaces and changes in blood circulation. This is the zone of thermoneutrality. In the region above this temperature zone, cattle must increase their heat dissipation to maintain their body temperature.

Because of its importance to tropical agriculture, most recent work has been directed to investigating this region where the problem of heat loss is paramount. It is with this work that the present article is mainly concerned.

Preliminary Research into Effects of Rises in Temperature and Humidity

Work on the more fundamental aspects of heat loss in cattle at high environmental temperatures and humidities has been in progress at the Hannah Institute for some years, and the results of this work will shortly be published in detail. To do such work it is necessary to have a room in which the animals can be subjected to various combinations of temperature and humidity, and in which the temperatures and humidities can be controlled within exceedingly fine limits. A pilot plant room of this type, known as a psychrometric room, has been built at the Hannah Institute. The complexity of this facility may be judged from the photographs shown in the art inset, which show the psychrometric room and the associated observation control room. The details of these rooms have already been described elsewhere [1]. Temperatures from 20 to 40° C., or beyond, can be maintained within the psychrometric room at any given level with an accuracy of ± 0.1° C., and any humidity, from that of the external air at 15° C. to saturation at any temperature, can be maintained within similar close limits. The rectal temperature, skin temperature of up to twenty-four regions of the body, scrotal temperature, respiration rate and heart rate can all be continuously and semi-automatically recorded in the observation room, thus excluding any effect which the presence of the observer might have on the animal.

The broad general results of the work done in this room on 4-month-old Ayrshire bull calves, all on the same plane of nutrition, has been to show that, as judged by respiratory and heart rate behaviour and rectal and skin temperatures, air temperature and humidity have only a slight effect on the animal up to temperatures of 30° C. Beyond this temperature and up to 40° C., respiration rate and skin and rectal temperature rise rapidly, and their rate of rise is accentuated by increases in humidity. The rise in respiration rate with increasing air temperature is astonishing. From initial values of 20 respirations per minute at 20° C., the rate increases to 220 per minute at 40° C. and 88 per cent relative humidity. Heart rate is largely unaffected until abnormal rectal temperatures of about 104° F. are attained, when it rises precipitously. The experiments have also shown that not only the magnitude but also the duration of the heat stress to which the animals are exposed is important. Very large variations in behaviour have also been found between one animal and another, so that in a group of Ayrshire calves all of the same age and fed similarly, some are tolerant of heat stress and others, judged by these experimental procedures, are intolerant. It may be that different heat productions, different thermal insulations of the coat cover, different degrees of ability to vaporize moisture, or different thyroid activities

are the explanation of these variations. Work now being pursued will attempt to define which of these possible causes are responsible.

Structure and Blood Supply of Skin

Simultaneously with this climatic research, histological studies on the structure of bovine skin have also been pursued at the Hannah Institute. Man's chief heat loss mechanism under high heat stress is sweating. It was thought that the reason for the high heat tolerance of tropically-bred cattle might be that they possessed different types of sweat glands from those of temperate-bred cattle, and perhaps more of them. A search of the literature up to 1950 showed that little or nothing was known about sweat glands or sweating in cattle [1]. A long series of investigations dealing with the sweat glands of Ayrshire and Zebu cattle, their nature, histochemistry, distribution and comparative morphology, was therefore undertaken. Because of its importance in heat dissipation, studies on the blood supply to the skin were also incorporated. The results of these studies have now been published [2, 3, 4, 5, 6 and 7]. They show that both temperate-bred and tropically-bred cattle possess the same type of so-called sweat glands, i.e., one to every hair follicle. These glands, however, are unlike those of man in that they are histologically unsuited for the secretion of large amounts of fluid, and have a meagre blood supply. They are, nevertheless, functional glands and not vestigial structures, although their function and the stimuli which causes them to function are as yet unknown. The same workers [8] have also shown that the vascular supply to the skin of temperate-bred cattle is well adapted for the conservation of heat in a cold environment. Other work now in progress at the Institute is tending to show that the ears of cattle possess histological structures in their vascular supply which may be of importance in body temperature regulation in the bovine.

Effects on Productivity of Temperate-bred Cattle

Apart from the export of cattle from this country to the tropics, the aspect of climatological research which is of importance to animal husbandrymen, farmers and agricultural advisers in this country, is that branch which deals with the effects of climate on the productivity of dairy cattle of temperate breed, since it has an important bearing on the best ventilating conditions in byres for optimum production and the health of the animals.

The results of much work on the physiology and productivity of Jersey and Holstein cattle has recently been published in the United States on this aspect of climatology [9]. The Jersey and Holstein dairy cows used in these studies were subjected, in a psychrometric room holding six animals at a time, to temperatures ranging from 0 to 105° F. The broad, general conclusions that may be derived from the U.S. results may be stated as follows : the optimum temperature for milk production was found to be 50° F. at relative humidities between 60 and 80 per cent ; above 70 and below 40° F., milk yield began to decline and, as usual, the result of the decline was to increase the butterfat percentage ; above 75° F. food consumption decreased, water

consumption increased and the cows lost weight; at 105° F. food consumption and milk production virtually ceased.

In the range 50-105° F., the respiration rates of the cows increased sixfold; pulse rates tended to decline, except when the rectal temperature rose to abnormal levels, when they increased; heat production decreased by 30-40 per cent and rectal temperature increased by as much as 7° F. above the normal level (101° F.) at 50° F. It is important to note that in the range of air temperature from 5 to 95° F., respiratory vaporization rose from 4 to 30 per cent of the total heat dissipation, and that between 50 and 80° F. surface vaporization rose fourfold, accounting, at 85° F., for 75 per cent of the total heat dissipation. Despite all these increases, this combined vaporization was insufficient to prevent a rise in the rectal temperatures of the cows.

As a result of these experiments, the American workers have been able to draw up prediction curves, from which the moisture output of lactating Holstein and Jersey cows may be derived in pounds per hour per cow. Examples of the moisture output of a 1,000 lb. Jersey or Holstein cow at temperatures which might be encountered in byres in this country are given in the following table.

Output of Vaporized Moisture at Different Air Temperatures for 1,000 lb. Jersey or Holstein Cow.

Temperature (*deg. F.*)	Moisture (*lb. per hour per cow*)
40	0.5
50	0.6
60	0.8
70	1.4

*Taken from data in Bulletin 479 of the Mo. Agric. Exp. Sta. [10].

Significance of Work in Cattle Byre Designing

Earlier work on the ventilation of cattle shelters [11] showed that in normal byres, provided adequate ventilating systems were used, a temperature of 50° F. was readily obtained. At that time, however, no physiological basis for choosing 50° F. as the optimum temperature could be given. The recent American work cited above supplies this basis. From these moisture-prediction figures, and the known heat productions of dairy cattle, it should now be possible to design and construct byres for any given number of cattle to secure the best possible temperature and humidity conditions within the byre for milk production and human comfort. An important point is that cows of European breed can tolerate cold much better than heat. They can even be kept at 0° F. without seriously affecting their productivity. Any temperature above 70° F., however, will have a very significant effect on their production. It may be that humidity has an effect on the health of cows, although there is no substantial evidence to show that within the temperature range likely to be encountered in byres in this country, excessive humidities would have any effect at all except on the fittings of the shelter. Adequate air movement, nevertheless, should be provided, since in a byre holding, for example, twenty-four cows, about 15 lb. of vaporized moisture per hour must be disposed of to prevent unduly stuffy conditions.

Measuring Heat Tolerance

Reverting to the question of the heat tolerance of temperate and tropically-bred cattle, these same American workers [9] have shown that the " critical " temperature for decline in milk production and for effect on physiological processes in Brahman cattle is about 90 to 95° F., compared with 80° F. for Jerseys and Holsteins. The reasons for the increased heat tolerance of the tropical Brahmans are imperfectly understood. It is known that they have a 12 per cent greater surface-area to body-weight ratio than the temperate breeds, principally because of their large dewlap and pendulous sheath, and claims have been made that their basal metabolism is less than that of temperate breeds. However, since some temperate-bred cattle have as high a heat tolerance as tropical cattle, and since tropical cattle also vary in their heat tolerance, it may be that there is an intrinsic difference in their heat-regulating mechanisms.

The term " heat tolerance " has been widely used in the literature of bioclimatology. By a heat-tolerant animal is meant one which, by various means, can eliminate large amounts of excess heat and allow productive processes to proceed even at high air temperatures. Any physiological measurement of reaction to heat stress can, therefore, be related to heat tolerance only if it is first found to be closely related to productivity. Ultimately, it would also be of great value if a simple measure of heat tolerance, related to productivity, was found to be inherited, since animals could then be readily selected for breeding for high heat tolerance.

Before a simple measure of heat tolerance can be found, much fundamental work on the regulation of temperature in the bovine, and on the nature of heat stress, must be done. It is with this fundamental aspect, and with means for ameliorating the effects of temperature on cattle, that the present work at the Hannah Institute is concerned. This latter aspect of the work may have an important bearing on the export of cattle from this country to the tropics, and on the conditions under which cattle are kept during transport.

A test of heat tolerance widely used is the Iberia heat-tolerance test, whereby the adaptability of an animal to the tropics is judged by the extent by which its rectal temperature rises after a day in the sun at 90° F. The adaptability is obtained from the formula: $A = 100 - 10(BT - 101.0)$ where A is the adaptability and BT is the temperature of the animal after a day at 90° F. in the sun. The accepted normal temperature of the bovine is 101.0° F. On this basis, a perfectly adapted animal would have an adaptability of 100. With this scale it has been shown that the adaptability of American Brahman dairy cattle is about 90, the Santa Gertrudis breed about 80, and the Aberdeen-Angus dairy cattle about 59. But the test has not yet been decisively related to productivity and therefore has, as yet, little practical value.

Many workers have investigated means of ameliorating the heat stress put upon cattle in the tropics. It has been found that grazing the cattle at night materially helps their productivity because they do

not have the burden of their own heat production added to by the tropical sun. The provision of shade by trees, or, better, by shelters with hay-insulated roofs, also helps; sprinkling water over the animals markedly improves their heat dissipation. Such methods, however, are not always feasible, for they often require the provision of extra labour or facilities, such as plenty of water, which may not be available.

Summary

It may be said that research on the effects of climate on cattle is concerned with three objects. Firstly, the elucidation of fundamental knowledge concerning temperature regulation in the bovine, which is largely the province of the physiologist and biophysicist; secondly, the application of such knowledge to the ventilation of byres in terms of the comfort and productivity of cattle—largely the province of the architectural engineer and animal husbandryman; and, thirdly, the application of such knowledge by the breeder in the tropics and the geneticist, so that the production of food in the tropics may be greatly increased.

The defining of 50° F. as the optimum temperature for milk production is of great significance to designers of byres in this country and to the farmers who use them. Futhermore, it is now possible to design such shelters on a sound physiological basis, for the necessary data on which design should be based are now available.

The subject of bovine climatology is as yet in its infancy. Much more fundamental work will have to be done on the physiology of the bovine before practical advantage can be taken of what is, as yet, but dimly concerned.

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ESTIMATING THE FROST RISK OF AN ORCHARD SITE

L. P. Smith

Agricultural Branch, Meteorological Office

The Meteorological Office maintains records of the day-to-day air temperature measured under standard conditions at their official and officially recognized stations, from which it is easy to extract the frost frequencies in the form of long-term averages. Such frequencies can apply only to the sites in question; they cannot be used with any degree of confidence for other sites in the neighbourhood because of the very local nature of frost incidence. The practical problem of estimating the probable frost risk in a given field has been the subject of research by the Agricultural Branch of the Meteorological Office, and a recent article in the Meteorological Magazine* has described a method by which standard observations from official stations can help to provide an answer.

Briefly the method is as follows. In the area under survey, night minimum (screen) temperatures are observed at one or more points during the late spring frost period (April and May) for at least one year. From these observations it is possible to obtain the average daily minimum temperature and the average weekly minimum temperature for each week (the weekly mean minimum and the weekly lowest minimum). Over a short period of 1-3 years such figures are of limited value, and therefore they are " weighted " with respect to the contemporary and long-term records of a nearby standard station. After weighting, the results are " smoothed " by the use of prepared curves which illustrate the normal rate of increase of these average minima with time of year, thus giving a close estimate of the required long-term averages of minimum temperature on the site. The algebraic difference between these two derived sets of averages gives the " spread coefficient ". Finally, use is made of prepared diagrams whereby, from the averages of mean daily minima and the spread coefficients, an estimate of the frost frequency in any one week can be made. The basic principle underlying the diagrams, which are based on observed data, is that the lower the average mean daily minimum and the greater the spread (or average deviation below the mean minimum), then the higher is the frequency of frost.

It is interesting to apply this method to a frost liability survey that was carried out at the Experimental Horticulture Station at Luddington.† The area under survey was the south-west slope of a hill bounded on the south and south-west by the Avon; the slope is convex at the upper levels and concave at the lower. Members of

*Estimation of Weekly Frost Risk using Weekly Minimum Temperatures. E. N. Lawrence. *Met. Mag., Lond.*, 1952, **81**, 137-41.

†An aerial picture of the site appeared facing page 68 of this Journal, No. 10, Winter 1950.

the station staff took daily records of night minimum temperatures at six sites during the springs of 1950 and 1951. The positions are shown in Figure 1. Sites I, III and IV were in operation for both years; the standard weather station operated during 1951 only. Site II was used for 1950 only; the instruments were placed at Site IIa during 1951 because in this position there was a shallow saucer of ground which might have proved to be a local minor frost hollow. Standard minimum thermometers were used; one was exposed in a standard screen at the crop weather station, the others were in modified shielded mounts at the usual height of four feet above ground. Corrections were applied to the readings from the shielded mounts to allow for the slightly different form of exposure. Long-term averages of temperature were available from the records of the nearby crop weather station at Drayton Manor (Grassland Research Station).

Fig. 1. Sites of weather recording units at Manor Farm, Luddington

The averages of mean daily minima and mean weekly minima were weighted (with respect to Drayton Manor observations and averages) and smoothed in the way indicated earlier—with the results shown in Table 1.

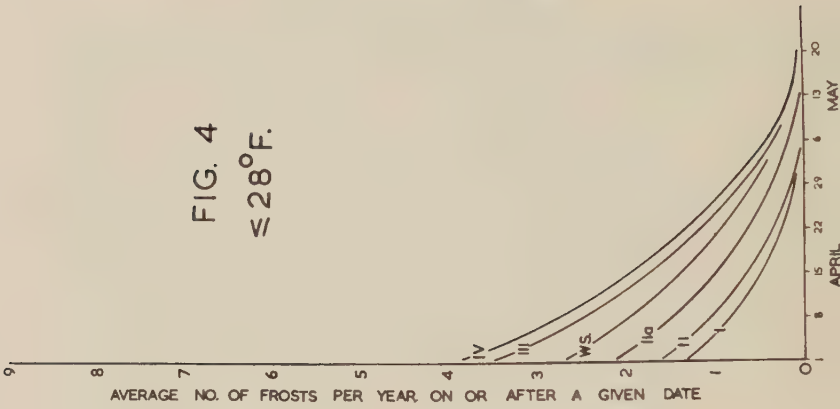
The frost frequencies for each of the eight weeks and each of the six sites can now be estimated for threshold values of frost intensity 32, 30, and 28°F. The frequencies on or after a certain date are shown in Figs. 2, 3 and 4 on p. 294; the frequencies per ten years after March 31 and April 30 can be summarized as in Table 2.

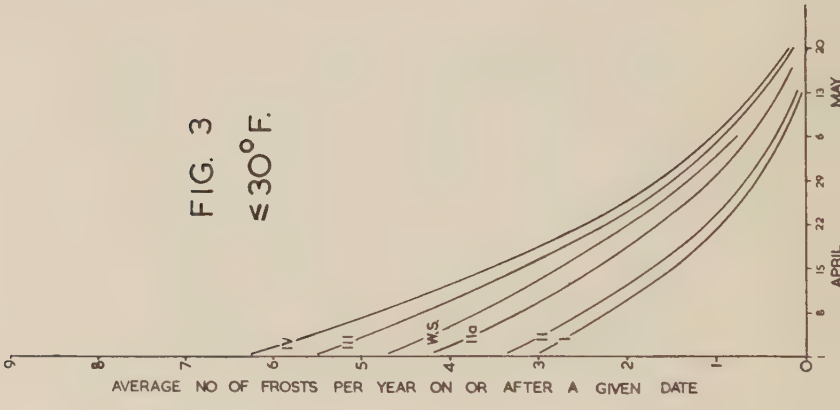
Table 1. Weighted and Smoothed Average Temperatures at the Various Sites

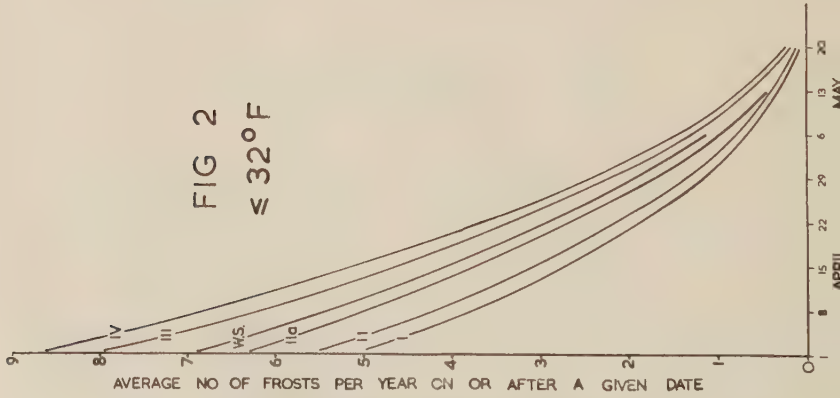
Period	Site						
	I	II	IIa	III	IV	Weather Station	
April 1-7	38.6	38.3	37.8	37.5	37.0	37.8	Average minimum (°F.)
	31.2	31.0	30.6	29.6	29.1	30.4	Av. lowest min. (°F.)
	7.4	7.3	7.2	8.1	7.9	7.4	Spread (°F.)
April 8-14	39.0	38.7	38.3	37.9	37.4	38.3	Average minimum (°F.)
	32.0	31.7	31.1	30.2	29.7	31.0	Av. lowest min. (°F.)
	7.0	7.0	7.2	7.7	7.7	7.3	Spread (°F.)
April 15-21	39.7	39.4	39.0	38.5	38.1	39.2	Average minimum (°F.)
	32.8	32.5	32.0	31.0	30.7	31.9	Av. lowest min. (°F.)
	6.9	6.9	7.0	7.5	7.4	7.2	Spread (°F.)
April 22-28	40.4	40.2	40.0	39.4	39.0	40.0	Average minimum (°F.)
	33.7	33.4	32.8	32.8	32.6	32.7	Av. lowest min. (°F.)
	6.7	6.8	7.2	7.4	7.4	7.3	Spread (°F.)
April 29 to May 5	41.3	41.1	40.9	40.3	39.9	40.9	Average minimum (°F.)
	34.8	34.4	33.8	33.0	32.7	33.6	Av. lowest min. (°F.)
	6.5	6.7	7.1	7.3	7.2	7.2	Spread (°F.)
May 6-12	42.4	42.2	42.0	41.6	41.1	42.0	Average minimum (°F.)
	36.0	35.7	35.1	34.2	33.9	34.9	Av. lowest min. (°F.)
	6.4	6.5	6.9	7.4	7.2	7.1	Spread (°F.)
May 13-19	43.7	43.5	43.4	42.9	42.5	43.4	Average minimum (°F.)
	37.6	37.3	36.6	35.8	35.5	36.4	Av. lowest min. (°F.)
	6.1	6.2	6.8	7.1	7.0	7.0	Spread (°F.)
May 20-26	45.3	45.1	45.0	44.5	44.0	45.0	Average minimum (°F.)
	39.4	39.1	38.5	37.7	37.3	38.3	Av. lowest min. (°F.)
	5.9	6.0	6.5	6.8	6.7	6.7	Spread (°F.)

Table 2. Estimated Frost Frequencies
(per ten years)

		Site					
		I	II	IIa	III	IV	Weather Station
After March 31	≤ 32°F.	51	56	64½	71	88	70½
	≤ 30°F.	30½	34	42½	56½	63	48
	≤ 28°F.	14	16½	21½	35	38½	27
After April 30	≤ 32°F.	10½	12½	15½	20½	22	18½
	≤ 30°F.	5	6	9½	14	15	12
	≤ 28°F.	1	1	3	6	7	5







Figs. 2, 3 and 4. Estimated long-term frequency of frosts at Luddington

The decision as to where to plant the top fruit at Luddington had to be made long before this survey and analysis were completed, and the general lines of this decision are indicated in Plan No. II on p. 61 of issue No. 10 of this Journal (Winter 1950). It is interesting to note that the present attempt at detailed analysis apparently confirms the wisdom of that decision.

It may be concluded that the present method provides a means of estimating the frost risk of a proposed fruit plantation or orchard. The taking of minimum temperatures over a limited period may guard against the acceptance of an uneconomic frost risk and the consequent wastage of capital expenditure.

Thanks are due to the Director and staff of the Luddington Experimental Horticulture Station for the time they have spent, and the care they have shown, in taking the necessary observations.

ABSTRACTS

ANIMAL BREEDING

The Sixth International Congress of Animal Husbandry was held in Copenhagen in July. One section of the Congress was devoted to " present viewpoints on breeding methods," and " pure-line breeding and cross-breeding." The published report of the proceedings of this section provides a collection of papers as varied in style and content as the countries from which they come.

Two long and general papers presented by Dr. Engeler from Switzerland and Professor Hazel from America were followed by more specialized contributions from twelve other countries. Several speakers took the wise precaution of defining their nomenclature and providing equivalent terms in French, German and English. So, with little chance of misunderstanding, the protagonists of pure- and cross-breeding held forth.

Only a few of the delegates reported on the results of new breeding experiments. The most unusual and promising cross described was one between the yak and domestic cattle which apparently excels both parents in meat production under the conditions in Mongolia.

The majority of papers review—with no small amount of partisanship—experiments which have already been published.

Firstly, the arena may be cleared of breeding policies which met with general approval. The crossing of European and native cattle to provide stock for the tropical and sub-tropical regions of the world is a case in point. But even here there was a difference in viewpoint. Are we to regard this cross as a grading-up of native cattle, or as a means of improving the adaptability of European cattle to tropical environments ? Whichever way we look at it, cross-breeding, as Professor Nichols pointed out, provides a rapid means of filling any economic niche produced by changing conditions. By pure-breeding these cross-bred

animals, new breeds can be formed. During the nineteenth century many breeds were formed by this process, but in recent decades successful new breeds have been common only in the U.S.A. and the Soviet Union. Unfortunately, there was no paper from Russia, for it would have been interesting to hear how divergent theories of genetics have led to similar practices. In general, cross-breeding for the production of meat animals was also approved but not without the inevitable objection due to the difficulty of obtaining pure-bred replacements.

The real division of opinion came over the question of breeding from cross-bred animals. The pure-breeders maintained that the breeding value of cross-bred animals was far less than their own performance. Yet other delegates quoted with approval the use of half-bred ewes (Cheviot x Border Leicester) for mating to Down breeds of ram. The cross-breeders even advocated criss-crossing and rotation-crossing using two and three breeds alternately, but could draw no comment from the pure-breeders on this heresy. Pure-breeding has given good results as shown by the improvement in national averages, so why change this policy ? The reply was that genetic improvement by pure-breeding can only be very slow for many characters of economic importance. Cross-breeding has its possibilities for such characters in the selection of crosses that exhibit hybrid vigour. How large an initial improvement can be made by this means is unknown, but still more important is our lack of knowledge on the long-term improvement possible.

The final paper of the proceedings by Dr. Zeller of Beltsville seems to indicate the way the wind is blowing. He described how the Danish Landrace was imported into the U.S.A. in 1934, and has been incorporated in several inbred lines which are now being utilized for cross-breeding. In this way, the results of pure-breeding are being used to effect a change from the lard type of pig to the desired lean animal, but in a way which would not be approved of in Denmark. The formulation of breeding plans obviously needs to be adapted to the needs of the situation and the kind of animal. No one policy of pure-breeding or cross-breeding is likely to be universally applicable, and unfortunately not all the delegates appear to have realized this fact. It is to be hoped that this conference did at least show them the complexity of the problem and the need for an open mind until both methods have been tried out by adequate experimentation.

J. W. B. K.

Report of the Second International Congress of Physiology and Pathology of Animal Reproduction and of Artificial Insemination. Kandrup and Wunsch. 1952, **1-3,** Copenhagen.

A number of genetic defects of livestock are considered in this report. J. L. Hancock (**2,** 35) describes the methods of examining semen from sterile Friesian bulls, which exhibited an abnormal acrosome in the sperm head. Sixteen of the seventeen bulls studied have shown a close familial relationship. B. V. Engelhardt (**2,** 48) describes malformations of the genitalia which are greatly reducing fertility in the daughters of one bull in the Black and White Lowland breed in Sweden. G. Götze

(**2,** 96) reviews generally the problems of lethal defects when A.I. is in use. He considers that A.I. is helpful in dealing with these conditions, as it draws attention to them and facilitates the tackling of the problem from the practical side ; but he considers that the continuation and further development of artificial insemination can only be justified if the rearing of healthy and efficient breeding animals is guaranteed as far as possible. P. Koch (**2,** 110) describes inherited cerebellar ataxia in foals, blindness in foals, cryptochidism in horses, leucaemia in cattle, and haemophilia in dogs. N. Lagerlöf and I. Settergren (**2,** 153) and N. Lagerlöf and H. Boyd (**2,** 164) discuss gonad hypoplasia in the Swedish Highland breed. This anomaly affects both sexes and is due to an autosomal recessive gene with incomplete penetration. During the years 1935-52, over 8,000 cows have been examined clinically. Following the adoption of a control policy, the incidence of hypoplasias fell from 17.5 per cent of animals born in 1936 to 9.4 per cent of animals born in the period 1946-48. R. W. Pomeroy (Addendum, 5) studies pre-natal mortality in an inbred strain of Large White pigs. Reduction in litter size is due to either fertilization failure or, more probably, death and resorption of early embryos. Outcrossing with out-bred boars suggests that the mortality was a characteristic of the inbred sows and not of the inbred embryos. J. A. Laing (**2,** 17) reviews embryonic mortality and considers that in general the effect of lethal hereditary factors can probably be excluded from consideration, although, on occasions, such factors may be responsible. It is less easy, however, to disregard the possibility in some females that there is an inherited tendency for embryos to die.

G. B. Y.

Distribution of Pedigree Ayrshire, British Friesian and Shorthorn Cattle in Great Britain in Relation to Temperature and Rainfall. G. Wiener. *Emp. J. exp. Agric.*, 1952, **20,** 123-32.

Much has been said about possible interactions between inherited differences in our dairy cattle breeds, and their various environments. The present paper attempts to discover the effects of mean monthly rainfall and temperature upon the milk yields and relative proportions by number of the three most numerous breeds of dairy cattle in Britain in 1946. Seven meteorological districts, used as environmental entities, were related to the proportional distribution in them of herds and females registered in the Ayrshire, British Friesian and Shorthorn breeds from 1945-46, and graphs were drawn to show the average monthly temperature and rainfall within each. Six districts of England and Wales included the majority of Friesians and Dairy Shorthorns, and the west of Scotland represented the home of the Ayrshires.

In relation to the other two breeds, Ayrshires were most numerous in north-east England, a district climatically most unlike their home, whereas they were not so favoured in districts climatically more similar to Ayrshire. The two districts in which Friesians predominated differed appreciably within the overall range. Shorthorns increased in proportion with increasing rainfall, but no real conclusions can be drawn without information regarding possible decrease in the drier

districts. From this evidence, therefore, it is difficult to decide whether or not climatic differences have in part determined breed distributions.

Breed milk production was estimated from the 1946 National Milk Records, and includes both registered and non-registered animals. The relative breed averages remained fairly constant, any differences between districts applying almost equally to all three. Possibilities of interaction between breeds and environment (as shown by meteorological districts) cannot therefore be demonstrated on this material. Further, climatic differences between districts were so small and the year-to-year range within them so large, that even the fact of highest yield concurring with lowest rainfall, and lowest yield with lowest temperature, cannot be adjudged significant.

K. v. O.

ANIMAL NUTRITION

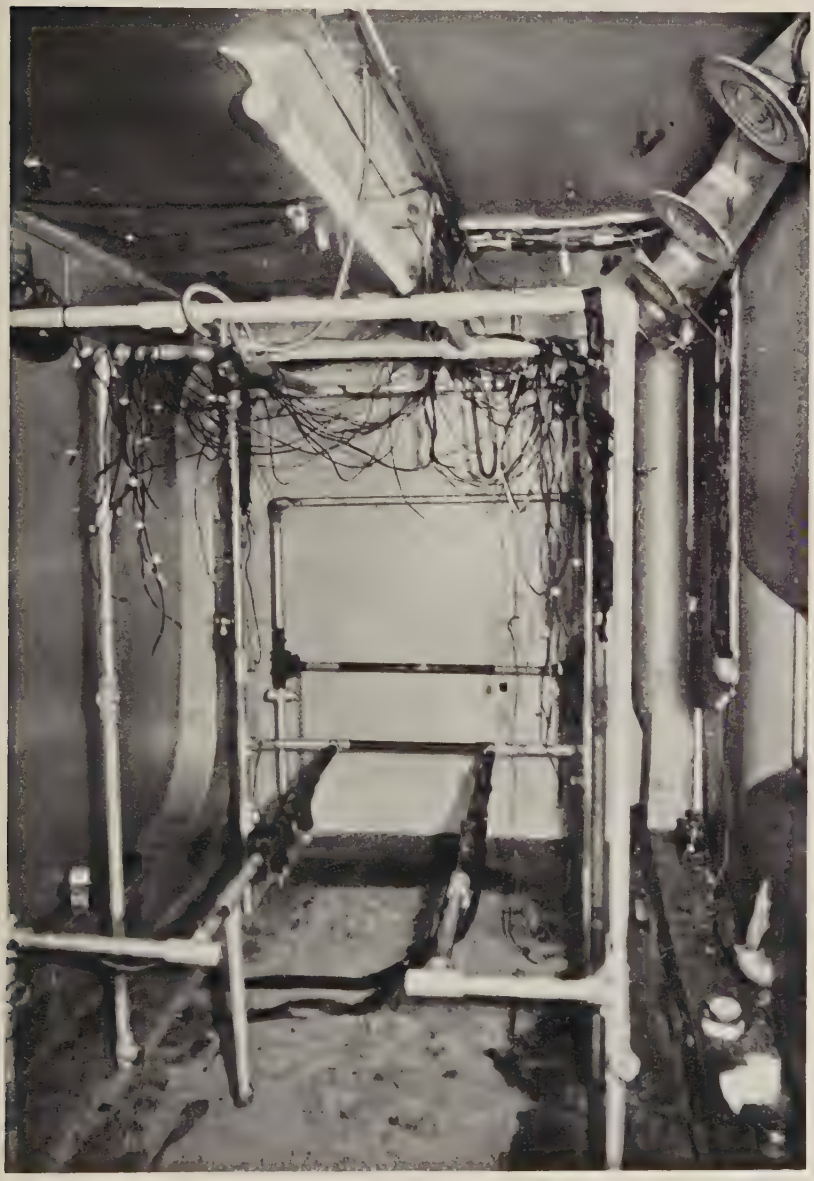
Vitamin A

A review by Eden [1] on deficiency of vitamin A in farm animals gives a very good account of present knowledge. Much of this knowledge (e.g., the relation of vitamin A to reproduction, growth, vision, health of epithelial tissues, etc.) has been well established for some years, but many points are still the subject of discussion and active investigation.

The theory that vitamin A can prevent white scour in calves has been advanced by some workers and refuted by others, but a recent report [2] suggests that it is effective only if accompanied by lecithin. Cows receiving vitamin A + lecithin transmitted much more of the vitamin in their colostrum than cows receiving it alone; calves given skim milk + vitamin A + lecithin were as healthy as those given colostrum; while calves given only skim milk + vitamin A scoured badly. (It is probable, however, that the real anti-scouring factor of colostrum lies in the protein fraction—see this Journal, Summer 1952, No. 16, 153-5.)

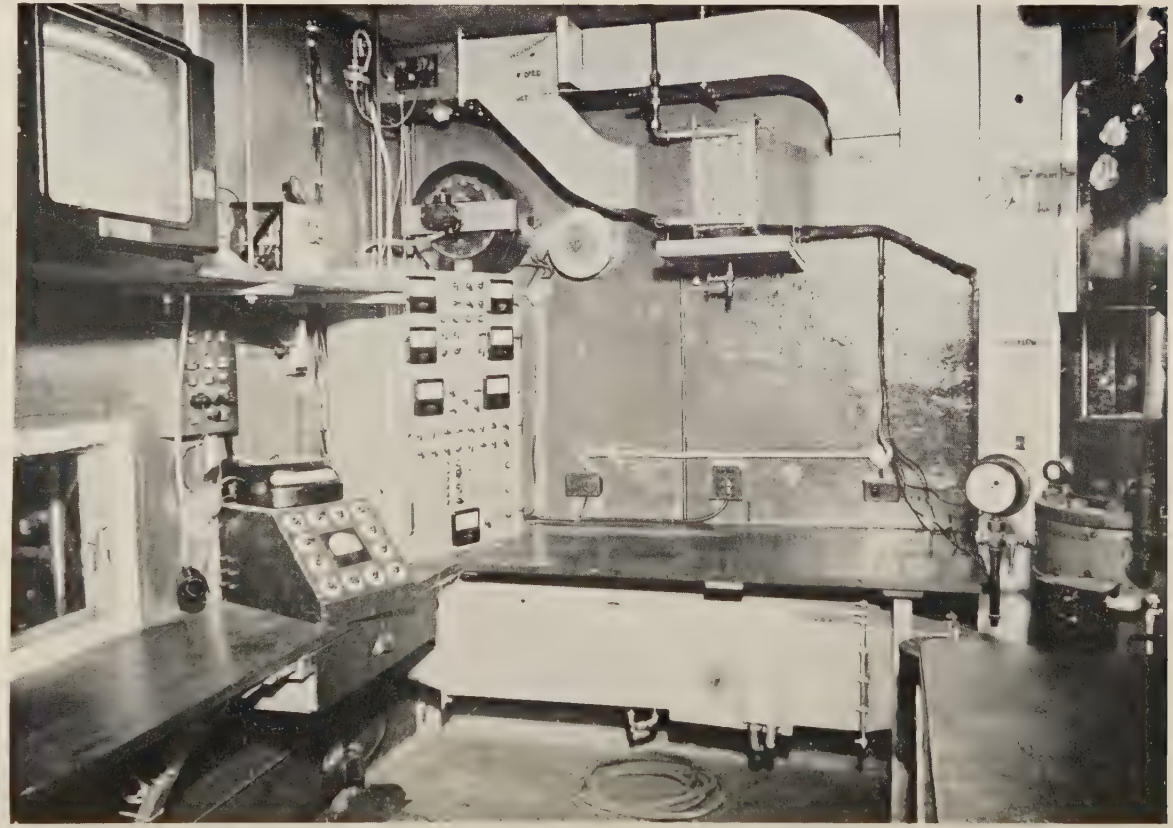
Cases of blindness in cattle have been found by Blakemore and his associates [3]. The damage to the optic nerve was caused by oedema through lack of vitamin A, and occurred on farms where a diet of straw, sugar beet pulp and cattle cake was being fed.

Apart from vitamin A present as such in the colostrum and milk taken in early life, an animal normally obtains its vitamin A from the carotene associated with green foods. Ferguson [4] has quoted the requirements of animals of various live weights in terms of the minimum estimated requirement multiplied by 5 (to provide a margin of safety), and has calculated that small quantities of dried grass of only moderate carotene content (20 mg./100 grm.) will suffice. Thus 1 lb. of dried grass could cover the needs of a fully-grown bovine, and 1½ oz. would be enough for a 100 lb. calf. Small as these amounts may be, it is important that green foods containing adequate carotene should be fed. Pigs and poultry may also derive their requirements from carotene added as grassmeal or picked up on range from fresh greenstuff, but in their case fish oil is a common direct source of vitamin A.



The psychrometric room at the Hannah Institute

PLATE I



The observation and control room associated with the psychrometric room at the Hannah Institute

Vitamin D

Obvious symptoms of deficiency of vitamin D are to be found more commonly in pigs and poultry than in cattle. It is possible, however, that borderline cases may occur in the latter, indicated by subnormal growth rates. Vitamin D is made by the ultra-violet light in sunshine acting on sterols present in plants or in the skin of the animal. It follows that in areas deficient in sunshine or skyshine, the animal will get much less vitamin D, direct or in homegrown fodders, than in more favoured areas. Further, the physiological state of the plant determines the amount of the vitamin formed. Thus workers in the U.S.A. [5] have found that fresh lucerne leaves had only a trace of it, but half-dead leaves had 295 I.U. (International Units) per lb., and dead leaves had 2,700 I.U. per lb. Even artificially dried herbage will therefore have some vitamin D, the amount being proportional to the old stem and dead leaf present; similar considerations apply to silage, especially if wilting has occurred before ensiling. In one experiment [6] it was found that sun-cured hay fed at the rate of 1 or 1½ lb. per 100 lb. liveweight produced normal mineralization of bone in calves.

A reminder that climatic conditions in Britain (latitude 50-60 degrees N.) are much less favourable for vitamin D synthesis has been included by Abrams in a valuable review [7] which should be consulted direct for the large amount of information it carries. Abrams suggests that whereas cloudless skies might produce 600 and 350 I.U. per sq. cm. of surface per annum at latitudes 50 and 60 degrees N. respectively, in Britain the figures would more nearly be 220 and 130 I.U. In terms of average daily synthesis in a 1,000 lb. animal, this would correspond to 4,500 and 3,000 I.U. at the latitudes stated, but the calculation could be upset by differences in husbandry methods : e.g., the complete housing of cows in the winter months. The present emphasis on securing field crops in a green condition, i.e., rich in carotene, means that the yield of vitamin D from these may be less than anticipated. If a generous estimate of vitamin D in British hay is 300 I.U. per lb., then 10-15 lb. hay would provide at most 3,000 4,500 I.U. The daily requirement of a 1,000 lb. cow has been estimated at 5,000-6,000 I.U. In the case of high-yielding cows, the hay fed is at a minimum, and the intake of the vitamin could possibly be insufficient.

An interesting comment by Abrams is that herd infertility may be due not so much to absolute deficiency of phosphate, as to impaired absorption and utilization owing to insufficient vitamin D, and he holds that the vitamin status ought always to be taken into consideration.

Vitamin E

Deficiency of vitamin E in farm animals has been recognized as such only comparatively recently, but the symptoms have been known for many years. In Scandinavia, " fish flesh " or " waxy muscle " in calves, accompanied by muscular stiffness, has been ascribed to deficiency of vitamins B_1 and C, and muscular degeneration in foals accompanied by proteinuria has been thought to be due to excessive intake of protein ;

but the picture in both cases is typical of vitamin E deficiency. Blaxter and Brown [8] have written an excellent review of the place of vitamin E in the nutrition of farm animals, and it should be consulted for details.

Vitamin E consists of four naturally occurring tocopherols of which α-tocopherol is by far the most active biologically. An estimation of the total tocopherol content is therefore of only limited value, but recently methods have been developed for their separate estimation. Although vitamin E was originally associated with fertility through early work done with small laboratory animals, among farm animals only in the case of poultry is there definite evidence of its importance in reproduction ; the case of pigs is doubtful, and there is no evidence whatsoever for ruminants. The characteristic reaction of horses, cattle and sheep to deficiency is a hyaline degeneration of the skeletal and heart muscles resulting in pain, stiffness and abnormal posture (skeletal) or death from cardiac failure (heart).

A common feature is for the corresponding muscle on each side of the body to be affected (bilateral symmetry), with both showing white areas of degeneration [9]. The onset of this muscular dystrophy in calves can occur from the third week of life, the length of the lag usually reflecting the dam's tocopherol status. Spring calves tend to be affected sooner than autumn calves and it is notable that typical winter foods (hay, straw, cereals, roots) are many times poorer in vitamin E than summer pasture : a cow obtains probably ten times as much vitamin in the summer. There is an indication that dairy calves show a lower incidence of muscular dystrophy than beef calves, probably because of the better nutrition of their dams during pregnancy.

In sheep, the condition is known as " stiff lamb disease " [10], the symptoms being similar to those already described ; where the hearts of the lambs are affected the injury is in the right ventricle. The curative action of wheat germ and tocopherol in this disease has been known since 1936 [11].

There is evidence that chemical reactions take place between tocopherol and unsaturated fatty acids. Young pigs on a diet containing a large amount of fish scraps developed yellow fat, but the amount of pigment was reduced when tocopherol was given as a supplement [12]. Similar findings are reported by Robinson and Coey [13] who reared pigs normally until 30 lb. live weight, thereafter putting them on a vitamin E-deficient diet and giving supplements from 50 lb. live weight, as follows :

a. One oz. cod liver oil per week until 100 lb. live weight.
b. Cod liver oil amounting to 5 per cent of the meal ration throughout.
c. As for *b* plus 50 mg. tocopheryl acetate per day.

There were no external symptoms but, at grading, the back fats of those in (*b*) were yellow-brown and had an oxidized smell, while (*a*) and (*c*) were normal. The daily intake of cod liver oil in (*b*) and (*c*) was considerable, being $2\frac{1}{2}$ oz. at 70 lb. live weight, and double this amount at slaughter. In spite of this, 50 mg. tocopherol was sufficient to prevent visible defects in the fat of the (*c*) pigs and, although the fat had a higher iodine value, it had almost as much tocopherol as that of the (*a*) group

(2.8 mg./100 g. compared with 3.0); there was no tocopherol in the (*b*) fat.

It is interesting to compare this pig work with Blaxter's experience with calves [9] in which he states that 50 mg. of tocopheryl acetate were required daily to neutralize the effect of 15-18 ml. (roughly $\frac{1}{2}$ to $\frac{2}{3}$ oz.) of cod liver oil. There would appear to be a marked variation in the sensitivity of different species, and the quantities of cod liver oil given in normal practice to pigs and poultry are doubtless of great value for vitamins A and D and apparently without practical significance for vitamin E. In view of the possibility of other constituents of the ration affecting the functioning of vitamin E, it is not possible to state the quantitative requirements of the calf with certainty, but the following broad guidance may be given. The dam should be given green foods rich in tocopherol (fresh grass, dried grass, kale, *green* hay) during pregnancy, the calf should be encouraged to consume these same foods as early in life as possible, and the excessive use of foods rich in unsaturated oils should be avoided.

It is interesting to note that vitamins A and E follow each other closely in their natural occurrence, and they are also both prone to destruction by oxidation; it will be appreciated therefore that farm fodders rich in vitamin D (e.g., mature hay) are usually poor in vitamins A and E. Another interesting association is that vitamin E has a sparing action on vitamin A because the body reserves of the latter are depleted more quickly if the animal is deficient in the former vitamin.

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S. M. B.

MACHINERY

Fertilizer Placement

The efficiency of fertilizers may sometimes be markedly increased by placing them in bands alongside the seeds, so as to secure the benefits of high initial concentration of nutrients for the roots of the young plants. As a result of a large number of field trials and of extensive practical experience, the use of combined grain and fertilizer drills is now the established method for sowing cereal crops where small amounts of fertilizer are needed. With these machines the fertilizer and seed are sown down the same coulter, and it is only where large amounts of fertilizer are sown with the seed in particularly dry conditions that there is any damage to germination due to this " direct contact " placement. Some crops are, however, more susceptible to damage than others, and linseed, sugar beet, peas and beans are examples of crops which can suffer severely from contact placement of large quantities of fertilizer.

The 1951 Report of the Rothamsted Experimental Station gives results of research over a period of years by Cooke and Widdowson on fertilizer placement for peas (threshed and green), beans (winter and spring) and potatoes.

Experiments with Peas and Beans

In the case of peas and beans, a granular PK fertilizer was placed by means of a special drill about two inches to the side of the seed and three inches below the soil surface, and this practice was compared with equivalent dressings broadcast either at an early or late stage in preparing the seedbed.

On the average of all the experiments over four seasons, placing fertilizer beside the seed gave higher yields than broadcasting it, for both peas and beans ; the results being more marked with green peas than with the other crops. The conclusion drawn is that the use of suitable fertilizer placement drills would be profitable for farmers who grow appreciable acreages of such crops. As is pointed out in the Rothamsted Report of the previous year, such equipment, if available, could also be used without disadvantage for sugar beet and root crops in general. It would, of course, save the cost of applying the fertilizer in a separate operation.

Little progress has so far been made with manufacturing and marketing British side-band placement drills suitable for sowing peas and beans ;

so the advice that is given in the 1951 Report to those who have to employ broadcast methods is to work the fertilizer well into the soil at an early stage in seedbed preparation, or even to plough in the broadcast dressings, is of interest.

Experiments with Potatoes

Following earlier work on potatoes with a complex " fertilizer placement " machine in conjunction with hand planting (G. W. Cooke, *J. agric. Sci.*, **39,** I, 96-103), the 1951 Report gives the results of work by Cooke, Jackson and Widdowson using a simple planter with a fertilizer attachment specially made by the National Institute of Agricultural Engineering. Fourteen experiments were laid down in which the fertilizer (National Compound No. 1) was applied in the following ways :

1. Broadcast on the seedbed immediately before planting.
2. Placed in front of the seed-shoe of the planter.
3. Placed in contact with the seed.
4. Placed in one band beside and below the level of the seed.
5. Half the dressing broadcast and half placed in contact with the seed.

In all the experiments, the planter worked " off the flat " and completed the operations by covering the potatoes with a ridge of soil. Planting depth is not stated. The final position within the ridge of the fertilizer broadcast on the surface or placed in front of the seed-shoe was found to vary widely according to soil conditions.

On the average of all experiments, fertilizer placed in contact with the seed gave a slightly higher yield than side placement, while both of these methods, as well as method (5), were superior to methods (1) and (2). Emergence and early growth were seen to be checked by heavy dressings of fertilizer placed in direct contact with the seed, so the report advises farmers, who apply heavy dressings and use planters with fertilizer attachments, to take the precaution of applying only half the dressing in direct contact with the seed.

Though the results recorded in the report are only qualitative, it is understood that the differences, like those of the rather similar earlier experiments, were substantial. (In the earlier experiments the general relationship was that 10 cwt. per acre of fertilizer broadcast before ridging were required to produce average increases in yield equal to those given by 7 cwt. per acre broadcast after ridging, placed in side-bands, or placed in contact with the seed.)

It is also understood that repetition of the trials by the same workers during the 1952 season yielded results very similar to those already reported.

It is clear, therefore, that farmers who use simple potato planters which work off the flat, should pay particular attention to this matter of fertilizer placement. Until a cheap fertilizer attachment is produced which can be added to existing planters of this type, the best advice that can be given is to work the fertilizer well into the top soil, to plant the potatoes shallow, and to so arrange the covering bodies that the soil which contains the fertilizer is drawn in a small ridge around the potatoes—the formation of deep ridges being left to a later operation. Where planters

with fertilizer attachments are employed, it seems worth while to modify them to give side-band placement ; where this cannot be done, contact placement may be employed where soils are moist and fertilizer quantities are moderate. If, however, soils are light and dry, or the quantity of fertilizer to be applied is very high, and the machine cannot be modified to give side-band placement, half the dressing may be applied by contact placement and half broadcast in the normal manner.

Equipment for Fertilizer Placement

The equipment used in some of the experiments referred to above is described in an N.I.A.E. Report, C.S. 10/1187—*Equipment for Fertilizer Placement* with : (*a*) potatoes planted by hand ; and, (*b*) row crops grown on the flat and in ridges. This report gives an account of the development work which resulted in the production of successful experimental equipment for the earlier Rothamsted work on potatoes. It also describes the progress made from year to year with the machines used for fertilizer placement drilling of crops such as peas. This report covers developments up to the production of tool-bar-mounted seeder units which have been used by the N.A.A.S. in field trials during the 1951 and 1952 seasons.

Work in Other Countries

For those who wish to study work in other countries on fertilizer placement, there is very extensive American literature. Much of the important research work was carried out as much as 20-30 years ago, and a result of this has been the commercial development and extensive use of many kinds of fertilizer placement drills. A simple summary of American recommendations is given in a bulletin *Methods of Applying Fertilizer* (National Fertilizer Association, Washington, D.C., 1948) which contains the up-to-date recommendations of the National Joint Committee on Fertilizer Application.

C. C.

FRUIT

Sawdust Mulches

In parts of the United States of America and Canada where sawdust is readily available, horticulturists are exploring the possibilities of its use as an economic substitute for farmyard manure, green manure crops, and compost. Experiments in progress include the use of sawdust for surface mulching and, to a less extent, for incorporation in the top few inches of soil. Apart from the relative cost of the different mulching materials, consideration must be given to their possible beneficial or deleterious effects.

Amongst the fruit crops that have been mulched successfully are strawberries, raspberries, blackberries and hybrids, gooseberries, and currants.

H. F. Fletcher and others [1] point out that their experiments in British Columbia have not been running long enough to provide information on any but the immediate effects of sawdust. Hemlock sawdust is the chief kind available and hence most widely used : fir, cedar, alder, and cottonwood have also been used.

Sawdust mulch acts as an insulator, keeping the soil cool in hot weather and reducing temperature fluctuation. It reduces evaporation from the soil surface, and may improve soil fertility and texture. It does, however, remove soil nitrogen during decomposition. A 2-inch mulch usually suppresses annual weeds but perennial weeds may have to be destroyed before beginning the treatment.

In low rainfall areas fertilizers should be applied before the mulch, but applications on top of the mulch are effective if followed by rain or sprinkler irrigation. Partially decomposed coniferous sawdust, in large amounts, and cedar sawdust have proved toxic to plants in some cases.

Roberts and Stephenson [2] discuss the whole question of wood wastes as mulches—with special emphasis on sawdust, on account of its ready availability in Oregon. Of special interest are the experiments to determine the rate of decomposition and the amount of nitrogen needed in the process.

The rate of decomposition obviously depends on a variety of factors as well as the type of sawdust. Under the conditions of the tests, 3-4 inches of fir sawdust worked into the soil caused no further depression of nitrates after four years, whereas this degree of decomposition, as judged by the availability of nitrates, was reached in three years with alder sawdust. Tests with tomato and potato showed that 2,000 lb. sulphate of ammonia, or its equivalent, would be needed in the first year to offset the nitrate depression of 3-4 inches of fir or alder sawdust incorporated in the soil, but in the second year 1,000 lb. would be sufficient for fir sawdust, or 500 lb. for alder. In the third year it seems the quantities could be proportionately reduced. Strawberries seemed better adapted to sawdust, and the application of nitrogen could be as low as 500 lb. sulphate of ammonia during the first two years ; where fir sawdust was used as a mulch very little, if any, extra nitrogen was necessary to balance the decomposition process. There was no evidence of any considerable effect on soil *p*H.

These authors stress the importance of comparing the costs of management under sawdust mulch with those of the more usual methods.

J. J. Woods in British Columbia has been comparing the value of various mulches for some years. In a recent paper [3] the superiority of hay mulches (15 tons per acre in the first year and 7½ tons annually afterwards) over clean cultivation is shown for pears where, over the period 1942-50, the increased crop amounted to 10,341 lb. per acre per year. With cherries the results were inconclusive. With Boysenberries, a 2-inch mulch of sawdust, later increased to 3 inches, proved superior to cultivation, a grown cover crop, or hay mulch. A 3-inch sawdust mulch with loganberry gave crops 50 per cent greater than clean

cultivation. The sawdusts used were chiefly hemlock, cedar, and balsam fir. Some of these experiments are from unreplicated experiments, and even in the best of them the replication is low, so that the figures should be treated with caution.

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H. B. S. M.

GLASSHOUSE CROPS

The Steam Sterilizing of Soil (Its Physical Aspects and their Application). L. G. Morris. *The British Society for Research in Agricultural Engineering*, C.S. 14/1170.

This work was undertaken not only to provide knowledge on the fundamental nature of the heating process, but also to find answers to such questions as : whether the steam should be at high pressure or low ; whether the soil should be initially dry or moist ; how long the heating process should last, and how long the final temperature should be maintained ; and why some soils are more difficult to sterilize than others. Two types of soil were used in dry and moist states, and heating was given at varying rates by altering both the steam pressure and the size of holes in the perforated pipe. Measurements were taken for the evaluation of soil density, specific heat and heat capacity per cubic foot as functions of moisture content, and the rate of steam flow related to hole size and pressure. The heat capacity of compacted soil was found to vary from 24 B.Th.U./cu. ft. / °F. for dry, light soil (9 per cent moisture content) to 53 B.Th.U./cu. ft. /°F. for wet, heavy soil (58 per cent moisture). Steam flow (lb. per minute) was proportional to hole area and square root of pressure. To avoid wasting steam, at least twenty minutes should be taken for the surface soil to reach 212°F. Pressure should be controlled by a reducing valve, unless the boiler pressure is low enough to make this unnecessary.

Recommendations are made on the optimum state of division of the soil, its final temperature, heat required for different soils and moisture contents, boiler pressure, mains, fuel consumption, etc.—and suggestions are also made for future work in this field.

Steam Sterilization Studies. J. N. Davies and O. Owen. *Ann. Rep. exp. Res. Sta. Cheshunt*, 1951.

Changes in the production of ammonia and nitrate in undisturbed, unsteamed glasshouse soil and in two plots of steam-sterilized soil have been studied, one of these latter being dug over weekly, and the other

left undisturbed. Regular turning of steamed soil had the effect of hastening the onset of nitrification in comparison with undisturbed steamed soil, while ammonia disappeared rapidly. In contrast, ammonia concentration in the steamed, undisturbed plot remained high for long periods. In the undisturbed plots there was a marked accumulation of soluble salts in the surface soil, particularly in the top half-inch ; in the steamed plot the total was three times greater than in the half to one-inch layer. The reason for this is explained, and numerous figures and tables showing fluctuations in ammonia and nitrate nitrogen at varying soil depths and under varying periods of incubation are given.

The Microbiology of Four Steamed Soils. C. D. Oxley and E. A. Gray. *J. agric. Sci.*, 1952, **42**, No. 4.

The profound chemical changes which occur in steam-sterilized soil afford a medium of special composition for organisms which survive the steaming, or which gain access from external sources, and whose metabolism further alters the chemical composition and structure of the soil. Not only the activities of the bacteria, but also those of soil Protozoa, which are predators of certain bacteria, and the abundance of other organisms—notably the algae, including diatoms—must also be considered. Both the microflora of the sterilized soil and the microbiology have to be studied before the post-steaming changes which may arise from biological activity can be assessed. In these experiments, four different soils were steamed in order to study the microbiological changes in relation to the chemical and physical factors, namely, the abundance of ammonia, nitrites, nitrates, the C/N ratios of two soils and the *p*H and moisture content of three, as compared with the controls. The aim was to determine, so far as possible, the nature and critical periods of biological activity up to a period of sixty-two days after steaming. In all soils the production of ammonia up to fourteen days after steaming was associated with increased biological activity, generally by multiplication of bacteria associated with multiplication of Protozoa. Production of nitrites and nitrates was associated with a similar biological activity. The investigations showed that despite the contrasting characters of the soils, the major chemical changes were almost wholly attributable to biological activity, and that after steaming the same general reactions occurred in all.

E. S.

FLOWERS

Influence of Daylength and Temperature on the Growth of Greenhouse Violets. Calvin G. Cooper and Donald P. Watson. *Proc. Amer. Soc. hort. Sci.*, 1952, **59**, 549-53.

Although violets are not often grown under glass in this country, in America they were at one time a popular crop ; difficulty in timing the crop to coincide with the demand, however, has led to a considerable decline in production. The investigations reported in this paper will

help to show how this difficulty may be overcome, and are distinctly suggestive for possible application in the British Isles.

It is well known that the sweet violet (*Viola odorata*) produces two types of flower—an inconspicuous cleistogamous flower of no commercial value, and the large, attractive chasmogamous flower of commercial production. The valueless cleistogamous flower is produced after exposure to a long-day length for an extended period of time, while the chasmogamous flowers are formed when the plants are exposed to a short photoperiod. Previous workers have suggested that temperature is also a factor in determining the type of flower produced.

In the work reported here, young plants of the variety Fries Favorite were potted in sterilized soil on October 15 and subjected to four different treatments : 50° F. night temperature, 8-hour photoperiod ; 40° F. night temperature, 8-hour photoperiod ; 50° F. night temperature, 16-hour photoperiod ; and 40° F. night temperature, 16-hour photoperiod.

The first response to day length was the production of small leaf blades on short petioles in the 8-hour photoperiod, making a much less vigorous plant in contrast to the large leaves and long petioles produced under long days. The number of leaves per plant was less at the lower than at the higher night temperature, but the individual leaves were larger.

Flowering began 8-10 weeks from the beginning of treatment ; under short days at both temperatures, flowers were all chasmogamous ; under the long photoperiod, flowers were all of the cleistogamous type. Flowers in the short-day treatment were significantly larger at the higher night temperature and more were produced, though the difference in this experiment was not significant. It would appear that short-day treatment (8-hour photoperiod) with a night temperature of about 50° F. is a combination capable of resulting in good-quality flower production.

It might seem that advantage could be taken of the luxuriant " long-day " foliage, while obtaining chasmogamous flowers by a period of long-day treatment followed by short photoperiods. Attempts to achieve this, however, were unsuccessful, as the long-day foliage dropped and was replaced by the smaller short-day type before chasmogamous flowers were produced.

R. H. S.

CROPS AND PLANT BREEDING

Polycross Technique

The name " polycross " has come into general use to describe a method of progeny testing in cross-pollinated crops, devised independently by European and American plant breeders. Selected plants whose progenies are to be tested are propagated vegetatively and planted together in isolation from other plants of the same species. Seed is harvested separately from each clone, and used for sowing a trial.

While the maternal parents of the progenies are, of course, known, all that is known about the source of pollen is that it is derived only from

selected parents. Wit [1] has obtained information about the spread of pollen in the case of perennial ryegrass (*Lolium perenne* L.). He took seed from clones in both replicated and unreplicated plantings. Some of the clones had rough culms and upper leaf-sheaths, a character which he found to behave as a simple Mendelian dominant. From the proportions of " rough " seedlings in the progeny of the " smooth " clones at various intervals from a " rough " clone, he estimated that 40 per cent of the pollen received by a row of 25 plants came from the two immediately neighbouring rows 40 cm. away ; 74 per cent was contributed by the three neighbouring rows on each side. This result shows that the pollen received by different clones in an unreplicated planting may be quite different. Since the object of the method is to compare the breeding behaviour of the seed parents, variation in the kind of pollen received is undesirable. Using the same character, Wit showed that by randomization and replication of the clones, a satisfactorily uniform distribution of pollen could be obtained—unless there were differences of more than a week in date of inflorescence emergence.

Discussing the use of polycrossing in grass breeding, Schaepman [2] points out that the replication of clones in the polycross field gives the breeder an opportunity to make reliable observations on their characteristics. He considers it desirable to arrange the clones systematically in the replications so that the four neighbouring clones are different each time, thus ensuring a wide sampling of the available pollen by each clone.

Determination of Variety

Since the lodicules of barley were found to be useful in identifying and classifying varieties, Bernhard [3] has examined the lodicules of many varieties of oats cultivated in France. He found that they differed in length and in the presence or absence of a narrow lateral process. Observations can be made on dry primary grains, the lodicules being removed with the lemma ; the lateral process is more readily discerned on fresh, turgid lodicules in the florets.

Rebischung and Karska [4] describe the variation in grain and seedling characters among varieties of wheat grown in France. They give three artificial keys for variety determination ; one based on grain characters, one on seedling characters, and a third on the combination of both.

Variety determination in white clover can be troublesome because of the wide variety of conditions in which it is encountered. Gausmann and Fuelleman [5] have drawn attention to a character which may be useful here. They found that in the petiole of Ladino clover the number of vascular bundles was 7.65 ± 1.57, while in a " naturalized white clover in Illinois " there were 4.22 ± 0.86. The frequency distributions for the two types did not overlap.

Van der Vaart [6] has studied the use of silhouettes of the first and second scale leaves of pea seedlings of fourteen varieties grown in Holland, including blues, marrowfats, duns and maples. He concludes that the scale leaves can be used in determining the identity of a sample, but intra-varietal variation would make it difficult to judge the purity of a sample.

Hereditary Effects of Grafting

The question of whether grafting can have any effect on the sexually-propagated offspring of either component of the graft continues to be vigorously disputed. One school maintains that such an effect is in principle impossible ; at the other extreme is the view that such effects are obtained and that they are essentially similar to the effects of sexual crossing. Reports of the latter type coming from Michurinist geneticists in the U.S.S.R. have led to repetition of the work in other countries. The most recent repetition and the most thorough so far reported is by Brix [7]. She worked with tomatoes—a favourite subject for this type of work. She studied fruit form in the self-pollinated progeny of a variety with plum-shaped fruits grafted on a potato-leaved variety with normal fruits, and also in the reciprocal graft. Fruit colour was studied in two grafts of Golden Queen (yellow fruit) on red-fruited varieties Mikado and King Humbert. Control progenies were usually grown from the same plant as had supplied the scion, a precaution to which Brix attached great importance. In some cases the control progeny was from a scion grafted on a stock of the same variety.

Forms representing a deviation from the normal for the variety in respect of the character studied, were obtained in all types of progeny. In each of the four types of graft studied, a higher proportion of aberrant plants was obtained after cross-grafting than in the controls.

In 3,814 offspring from the four types of cross-graft, Brix recorded 82 aberrant plants : from ungrafted controls she raised 3,619 offspring with 52 aberrants. This difference is statistically highly significant, but through faulty statistical technique, Brix judged it to be insignificant.

As regards a possible similarity between grafting and sexual hybridization, Brix was not convinced and observed that the types of aberrant plants found in progenies from cross-grafts were similar to those in the controls.

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5. Distinguishing Ladino from White Clover Plants. H. W. Gausmann and R. F. Fuelleman. *Agron. J.*, 1952, **44**, 96-7.
6. The Identification of Pea Varieties in the Seedling Stage. F. M. Van der Vaart. *Euphytica*, 1952, **1**, 29-33.
7. Untersuchungen über den Einfluss der Propfung auf Reis und Unterlage und die Möglichkeit einer Übertragung eventueller Veränderungen auf die Nachkommen. Käthe Brix. *Z. Pflanzenz.*, 1952, **31**, 261-88.

J. L. F.

Attention is drawn to a report of a symposium on the " Effect of Cold on Micro-organisms ", *Proc. Soc. appl. Bact.*, 1951, **14,** 211, and particularly to " Relation to Dairying " (*ibid.*, 216). The article " Rejection Tests for Raw Milk " by L. F. L. Clegg, *Dairy Sci. Abstr.*, 1952, **10,** 732, should also be read.

A Comparison of Roll-Tube and Petri Dish Colony Counts on Raw Milk. L. F. L. Clegg, S. B. Thomas and C. P. Cox. *Proc. Soc. appl. Bact.*, 1951, **14,** 171.

In a controlled and co-ordinated experiment at two laboratories, media from the same bulk, and a standardized technique, were used to compare the colony counts obtained with roll-tubes and the classical petri dishes. The results, treated statistically, showed that, in general, roll-tube counts were smaller than those on petri dishes, but the differences were not consistent from milk to milk. Replicate samples gave about the same variation in both methods when replicate sub-samples were examined. It was considered to be rather more difficult to count roll-tubes than petri dishes. The overall conclusion was that a standardized roll-tube technique may replace the petri-dish method with no great loss of accuracy. This may prove to be an important decision because of the economy and convenience of the former method.

The Bacteriology of Farm Water Supplies. A Study of the Colony Count in 48 hours at 37°. S. B. Thomas, Blodwen F. Thomas and Patricia M. Franklin. *Proc. Soc. appl. Bact.*, 1951, **14,** 121.

In the examination of controlled water supplies, the colony count at 37 °C. is given considerable weight in assessing quality. In this study it was found that in farm water supplies from rivers, streams, canals and unprotected wells, the count at 37 °C. was much higher than in water from springs, protected wells and upland surfaces. Few *Bact. coli* type I were found amongst the colonies isolated, and many acid and gas producers were found to resemble *Bacillus macerans*, an aerobic spore-former. It was concluded that, in the water supplies examined, the colony count at 37 °C. for 48 hours contributed little more useful information than that given by presumptive coliform tests at 37 ° and the *Bact. coli* test at 44 °.

The Role of Micro-organisms in Dye Reduction and Keeping Quality Tests. I. The Change in Dominant Bacterial Flora during Incubation at 37.5° and 22°, and the Part played by Staphylococci and the *Coli-aerogenes* Group. Ellen I. Garvie and A. Rowlands. *J. Dairy Res.*, 1952, **19,** 133.

The correlation between indirect (the methylene blue reduction test) and direct keeping-quality tests is not as high as might be expected. The authors, in seeking the reasons for this, studied especially the part played by staphylococci and the *coli-aerogenes* group. They also observed the changes occurring in the bacterial flora of milk samples kept at 37.5 and 22 °C.

After overnight storage at 14° C., staphylococci constituted only a small fraction of the flora, but the numbers increased at 37.5 and at 22°C. At the time of reduction of methylene blue at 37°C. (notably when this was 5 hours or more) staphylococci formed a major part of the flora, but at 22°C. at the end-point of the clot-on-boiling test, they constituted only a relatively small part of the total flora.

Some growth of *coli-aerogenes* organisms, which were only a fraction of the initial flora, took place at 37.5 and at 22° C. The extent of initial contamination appeared, however, to bear no relation to the time of dye reduction or to the time to reach the end-point of the clot-on-boiling test.

Achromobacteria and microbacteria were initially present in the milk samples in considerable numbers, but seemed to have little effect on either test. At 37.5°C. staphylococci, micrococci, and streptococci were encouraged, but at 22°C. it was mainly the lactic streptococci which were stimulated. If streptococci became dominant at both 37.5 and 22°C. different species were found at the end-points. These differences may account for the discrepancies between the results of dye tests at the higher temperatures, and keeping-quality tests at the lower temperature. Those types favoured by 37.5°C. may play a relatively insignificant part in milk spoilage in the household.

A. T. R. M.

POULTRY HUSBANDRY

Breeding

One of the problems arising from the increasing interest in turkey production is how the market can be supplied with birds of the weight required by the majority of consumers. It is held that today the demand in this country is for turkeys of small size. Unfortunately, turkeys exhibit extreme sex differences in body weight, with the females of most varieties weighing only 65 per cent of the male body weight at twenty-four weeks. These sex differences in body weight are discussed by W. E. Shaklee, C. W. Knox and S. J. Marsden in a paper entitled " Inheritance of the Sex Difference of Body Weight in Turkeys " (*Poult. Sci.*, 1952, **31,** 822-5). The authors found that with Beltsville Small White turkeys, families differed significantly in the amount by which the males outweighed the females. They conclude that the sex difference in weight is influenced by heredity, and, therefore, it would seem feasible to develop strains in which males and females approximate to the same weight at slaughter stage.

On an allied subject, F. A. Hays and E. W. Spear discuss the " Relation of Age of Parents to Mortality and Sex Ratio of Chicks at Eight Weeks " (*ibid*, **31,** 792-5). The data presented indicate that the age of the dams has a more pronounced effect on chick mortality than the age of the sire, chicks from pullet dams having a higher mortality than those from older

birds. Dam effects are held to be due to both genetic and physiological causes since the dam is responsible for the early nutrition of the chick ; sire effects can only be genetic in nature. The authors maintain that the age of the parents appears to influence the sex ratio of the progeny at eight weeks ; young parents give a lower sex ratio than yearlings or older parents. The mortality rate in chicks over the first eight weeks of their lives has a regulatory effect on the sex ratio over that period. If mortality is high, males succumb at a greater rate than females ; if gross mortality is low, both sexes die at the same rate. The high sex ratio observed in pedigree breeding flocks at eight weeks may be attributed to the extensive use of yearlings and older birds for breeding stock.

A paper by J. S. S. Blyth on " Degenerate Inbred Lines of Brown Leghorns and their First Crosses " (*Emp. J. exp. Agric.*, 1952, **20,** 133-41) is of topical interest. The writer describes the performance of four non-interbreeding lines and their first crosses. Three of the lines showed signs of inbreeding decay. Fertility was better in the inbreds than in the interline matings ; the mortality of the crosses was much reduced in comparison with the parental lines. The performance of the line-crosses were superior to the inbreds in sexual maturity, body weight, egg weight, viability and winter production, with the exception that the winter egg production of two of the best lines in the flock was not surpassed by the crosses.

Nutrition

Hatchability problems are now becoming matters of major importance, and W. Bolton in " Observations on the Vitamin Metabolism of the Common Fowl, I " (*Brit. J. Nutr.*, 1952, **6,** 71-5) discusses the partition of free and combined riboflavin in the tissues of the laying hen, with reference to the part of riboflavin in egg production. The writer gives an account of the partition of free and combined riboflavin in the various organs, and suggests that the magnum is the tissue most involved in the day-to-day mechanism affecting the amount of riboflavin in the egg.

The employment of antibiotics in poultry foods still continues to be the subject of a number of contributions. Much of the work reported relates to table poultry. H. D. Branion and G. W. Anderson give an account of their findings in " Antibiotics and the Growth of Ducks ", *Proc. Poultry Sci. Ass.* 41st Meeting (in the press) demonstrating that various antibiotics had no beneficial effect on growth or feed efficiency with duckling, although they influenced the caecal microflora population. D. C. Hall, H. D. Branion and S. J. Slinger deal with the effect of penicillin with chicks in a paper entitled " Influence of Environment on the Growth Response of Chicks to Penicillin " (*ibid*). They confirm the views of other workers that the antibiotic leads to no response with chicks in new housing. This position, however, was only maintained over the first three weeks, and some growth response is reported with the chicks in the new housing after the three-weeks stage, particularly with the highest level of antibiotic feeding. Employing penicillin with goslings, S. J. Slinger, E. S. Snyder, W. F. Pepper and G. W. Anderson refer in the " Effect of Penicillin on the Growth of

Goslings " (*ibid*) to the absence of growth stimulation in a basal diet to which grass clippings were added, although the same basal diet without grass clippings led to a significant growth improvement when the antibiotic was added. The results indicate that penicillin stimulates the early growth of goslings, and, while there is interaction between grass and penicillin, the antibiotic cannot completely replace grass.

R. C.

MYCOLOGY

Clover Sickness. W. A. R. Dillon Weston. *Ann. appl. Biol.*, 1950, **37**, 320-3.

In 1949 the author, with Miss Ives and Miss Ball, examined 162 clover samples, of which 138 were broad red, from fields in the eastern counties showing " clover sickness ". Clover Rot only was found in 62.3 per cent of the samples, Stem eelworm only in 11.6 per cent, while in 26.1 per cent some plants were infected with Clover Rot and others with eelworm.

In eight samples of this last group, Clover Rot and eelworm occurred in the same plant. Initial infection with Clover Rot starts in the autumn from ascospores liberated from the resting sclerotia. This initial leaf-spotting may easily be overlooked. Later, usually in spring, the last resistance breaks down and the plant rapidly decays. Most cases of " clover sickness " were found where the crop was grown frequently ; only 16 per cent of the cases occurring in fields where the interval between susceptible crops was over eight years. The appearance of Clover Rot in fields which had no previous history of the disease might be explained by infection by wind-borne ascospores, though experimental evidence was lacking. The use for bedding of litter contaminated with sclerotia would lead to the disease being spread with the manure. Examination of seed samples indicated that there was little risk of sclerotia being mixed with the seed. In Sweden the fungus was believed to persist in the soil or weeds, but in this country it has so far been recorded only on *Sonchus arvensis*. More information is required on the susceptibility of plants other than clover and beans, and also on the length of time the sclerotia may persist in the soil.

Clover Rot Investigations. M. Justham and L. Ogilvie. *Ann. appl. Biol.*, 1950, **37**, 328.

In the South-West, apothecia of *Sclerotinia trifoliorum* were produced mainly in October and November, with rotting of the plants usually occurring in March. The disappearance of the sclerotia from the soil may be accelerated by the use of some nitrogenous compounds, grass cuttings, and some plant extracts. Heavy rains delay spore discharge and cause decay of the apothecia, while dry weather favours their survival —thus much Clover Rot has often occurred in the spring following a dry November. Spread from plant to plant takes place mainly along affected leaf stalks, though the fungus may grow about 2 cm. over the

soil. It may persist in the plant until harvest time. Only once was the fungus isolated from surface-sterilized seed. The use of leafy white clovers such as S.100 instead of broad red in three-year ley mixtures has resulted in the disease becoming less common in the south-west.

A Technique for the Selection of Red Clover Seedlings Resistant to the Clover Rot Fungus, *Sclerotinia trifoliorum*. A. ERIKSON, J. H. CARR and D. L. G. DAVIES. *Nature*, 1950, 1023.

In the course of breeding work the following method was devised for testing the resistance to *S. trifoliorum* of large masses of seedlings. A culture of the fungus is grown on moist bran in Erlenmeyer flasks for two weeks. The contents of the flasks are then dried at 30° C. for 48 hours, powdered in a mortar, and can then be stored for a considerable time at 3-4° C. Seedlings for testing are grown in 3-inch pots, fifty per pot. When the first trifoliate leaves are formed, they are dusted with the powdered inoculum from a sugar sifter, and covered with a Copenhagen jar to ensure a saturated atmosphere. Symptoms appear in three days, and most of the seedlings are killed in a week. The survivors (about 1 per 1,000) are grown on for further testing, but no evidence is yet available on their resistance as mature plants.

Observations on the Biology of Clover Rot. A. R. LOVELESS. *Ann. appl. Biol.*, 1951, **38**, 642-64.

Clover Rot is widespread in East Anglia on both light and heavy soils. Infection takes place in the autumn by ascospores which produce the " non-aggressive " phase of leaf-spotting. In experimental conditions the ascospores germinated readily at 100 per cent relative humidity, and at temperatures of 15-22.5° C. The fungus may remain viable in the leaf spots for at least 16 weeks. Under favourable conditions the " aggressive " stage of the disease develops from January to March, causing rotting of the crowns. This phase is favoured by the presence of large quantities of inoculum, and takes place only in a saturated atmosphere at temperatures from 5-20° C. Humidity usually appears to be the limiting factor, and, in the seasons 1930-47, the severity of spring attacks was correlated with the rainfall of the previous December and January. Crop rotation is important in controlling the disease, but it may not be fully effective if heavily infected fields occur in the area. Grazing or cutting the crop in the autumn at the time of ascospore discharge may check the development of the disease, but this practice may itself damage the plants severely. The most effective control appears to lie in the production of resistant varieties.

NOTE. The question of breeding strains of red clover resistant to Clover Rot was discussed by Watkin Williams in this JOURNAL (1951, No. 12, 139-43).

H. E. C.

PROVINCIAL NOTE

THE STORY OF THE ROOT EELWORMS IN THE EAST MIDLANDS

A. Roebuck

National Agricultural Advisory Service, East Midland Province

Three species of root eelworms of the genus *Heterodera* have become important on farms in the East Midlands. They have only appeared in this area in fairly recent years, but records of their appearance elsewhere date back to the last century. It may be of interest, therefore, to follow their progress a little and to review what we now know of their incidence and control.

POTATO ROOT EELWORM (*Heterodera rostochiensis* Wollenweber)

Kühn first recorded this eelworm on a patch of potatoes in Germany in 1881. Zimmermann, in 1913, showed that soil sickness of potatoes in the Mecklenburg area was associated with this pest. By then, damage to the commercial crop was fairly extensive.

Massee is recorded as having found this eelworm doing damage to potatoes in Scotland in 1913. Taylor found it on the roots of sickly potato plants in Yorkshire, in gardens at Wetherby and near Leeds in 1917. The first recorded heavy attack in a field resulting in a virtual crop failure, was at Gamlingay (Cambridgeshire) in 1919.

In 1923, Strachan and Taylor discovered the eelworm on field crops in Yorkshire, and at South Cave it was found to be associated with a long-standing disease—locally called " dab "—which appeared to have been known since 1904. Then, intensive production of potatoes from 1914 onwards evidently resulted in a big increase of the eelworm population of the soil, and sick fields appeared in many of the main potato-growing areas. By 1923 the eelworm was being associated with these sick fields. The first fields in this province where crops were found to be failing and cysts were abundant, were in the Wainfleet district and along Trentside north of Gainsborough in 1925. Since then, this pest has spread relentlessly throughout farm and parish.

On allotments, it was found at Kirkby in Ashfield (Notts) about 1919, and at Kegworth (Leicestershire) and Belper (Derbyshire) in 1926. It can fairly be said to be present now on all old allotment fields, although its presence there does not seem to be a threat to farms, except when a farmer adds an allotment field to his holding.

The Watching Years

Although there were few records by 1925, it is obvious that the pest was widespread in the potato-growing areas by that time.

Nevertheless, the position from the point of view of the scientist was confused for many years. In Lincolnshire the early varieties seemed to be the first to suffer. Although cysts were present on the roots of sick plants, they were often more abundant on healthy plants in a neighbouring field. For years there was no relationship between cyst content of the soil and crop yields. Few believed the eelworm to be the sole cause of the trouble.

In order to get something definite, pot experiments were carried out in 1929 and 1930 at the Ministry's Plant Pathology Laboratory at Harpenden, Herts. These established the fact that typical potato sickness does not occur in the absence of the eelworm. On the other hand, potato plants could grow normally even when heavily infested. No correlation was found between the cyst content of the soil and the intensity of the sickness. The experimental evidence suggested that the sickness was due to an attack by the eelworm in conjunction with a soil factor : possibly a nutritional defect which was not made good by the ordinary manurial measures adopted in the potato-growing districts. From that time, no one denied the association of the eelworm with the disease.

In the years which followed, advisory entomologists developed a technique for taking samples from a field and floating out the cysts from a known quantity of soil. The reasons for the variable cyst counts soon became apparent. Cysts can be present on plants in a field without the plants showing any visible signs of attack. After such a crop is lifted, however, there is a considerable increase in the eelworm population. By repeated cropping with too short an interval, there comes a time when the eelworms reach a certain population level beyond which the crop progressively decreases to complete failure as the population increases.

At the present state of our knowledge, only a prolonged resting of the field can restore the possibility of getting a crop of potatoes after a serious failure has occurred. That is, the field must be rested until sufficient eelworms die and the population drops below the critical level.

Fertile land will support more eelworms before crop failures occur than will poor land. It follows, therefore, that a good farmer who uses fertilizers generously may get a crop with a population of eelworms which would seriously depress the yield on a farm where the farmer is less skilled or less able to get the extra fertilizers.

During the 1930s more and more fields in Lindsey and Kesteven were found to be infested with the Potato Root eelworm, always as a result of crop failures when infestation was high. It was obvious that only by diligent search through all potato crops could its distribution be found, and a survey of that kind would only apply to the particular year. As the potato crops were moved from field to field the survey would have to be repeated.

By the early 1940s it became evident that there were two main areas in Lindsey and Kesteven which were widely, and often very seriously, infested with the eelworm. One of these was the Isle of Axholme and the nearby warp lands on the east bank of the Trent; this abutted on a similar area in Yorkshire north of the Isle. The other area consisted of the fen parishes all round the border of the district of Holland; this area merges with Holland and the fen district beyond.

The Sampling Period

In 1943 we were able to detail staff to begin a survey, in co-operation with the farmers, the county staffs and the W.A.E.Cs, concentrated on the more badly-infested areas.

By using the method of finding the cyst content of the soil already mentioned, any field not bearing a potato crop could be sampled. To ensure a more even distribution of the cysts, potato crops were never sampled until after the crops were lifted and some cultivation done. Theoretically the sampling could go on all the year round, but, in practice, there are hold-ups during frosts and during the dry summer period when it is impossible to get the corers into the soil. In addition, it is not feasible to sample in maturing corn crops, etc.

This survey has continued to the present day and been accelerated until the physical limits appear to have been reached. The following table gives the results, together with a classification of the fields.

Results of Potato Root Eelworm Sampling,
(Oct. 1, 1943–Sept. 30, 1952)

Year	Acreage	No. of Fields Sampled	Degree of Infestation							
			Absent		Low		Medium		High	
			No. of Fields	%	*No. of Fields*	%	*No. of Fields*	%	*No. of Fields*	%
1943–44	3,064	263	—	—	—	—	—	—	—	—
1944–45	11,258	1,097	461	42	471	43	66	6	99	9
1945–46	7,070	696	382	55	160	23	50	7	104	15
1946–47	3,442	373	80	21	140	38	55	15	98	26
1947–48	3,682	414	132	32	131	32	54	13	97	23
1948–49	10,834	1,472	591	40	515	35	155	11	211	14
1949–50	7,524	1,185	590	50	360	30	126	11	109	9
1950–51	9,559	1,629	648	40	482	29	220	14	279	17
1951–52	8,293	1,542	699	45	457	30	167	11	219	14
Total	64,726	8,671	3,583		2,716		893		1,216	

Note. In the above table, a low count is 1-4 cysts in 25 grammes air dried soil; a medium count is 5-8 cysts in 25 grammes; and a high count is 9 or more in 25 grammes.

During the first few years we examined potato crops growing on sampled fields, in order to study the effect on the crop of known cyst counts. This enabled us to give advice on future cropping with confidence. We extended our survey in the winter of 1947 to include

Nottinghamshire where the pest had appeared. We have since sampled 584 fields in this county with an average of 3,154. The pest is now present in thirteen parishes—twelve in the north—and one near Newark.

By sampling their fields we can give farmers a picture of their farms. They can then base their cropping on the fields with either no eelworms or with low counts, and rest the others. A great deal of good is being done in this way, for the farmers are very co-operative. It is, however, merely a delaying action until such time as a treatment of the soil can be found.

In spite of our efforts, this pest is steadily enlarging its range from the two main focal centres—the Isle of Axholme in the north-west of Lincolnshire, and the fen parishes to the south-east of the county. Infestation is appearing northwards along the cliff from Lincoln, in scattered parishes on the Wolds, southwards in Nottinghamshire from its border with the Isle, and across Kesteven westwards to Nottinghamshire near Newark. Altogether, it is now in one hundred and twelve parishes in Lindsey and fifty-three in Kesteven. The infestation varies from a single field in a parish to parishes where nearly every field is infested and a high proportion of them definitely sick.

The infestation probably starts on fields through affected soil adhering to the planted tubers. Multiplication then occurs as crops of potatoes are taken. Since cysts become an integral part of the soil, it is difficult to see how the rest of the farm can be kept free once a field has become infested. Fortunately, the potato is the only farm crop affected, and so by suitable rotation the farm need not lose any crops.

During these years a great many trials have been made in an endeavour to obtain an efficient and economical method of control both in this province, in the country as a whole, and in various parts of the world. We are still without such a remedy, but research will continue until a method is found.

The question arises, of course, as to how much we achieve by sampling methods. We feel we are reducing the losses of individual farmers and reducing the intensity of infection in the sick areas. Slowly its distribution is being accurately traced, and farmers are becoming conscious of the need for a careful watch on the rotation. Only a fraction of the acreage under potatoes in any year can be sampled, so more good is done by sampling in the areas where it is likely to occur. The total acreage of potatoes grown in Lindsey, Kesteven and Nottinghamshire in 1951 was 113,729. We were able to sample 9,559 acres, or approximately 9 per cent of the whole.

Finally, it must be stressed that once the pest has been found, subsequent losses can be avoided if the rules of good husbandry are followed. Until a cure is discovered, the main problem is to find the eelworm and to give the farmers some guidance.

SUGAR BEET EELWORM (*Heterodera schachtii* Schmidt)

This eelworm became notorious in Germany during the last century. Sugar beet was first extensively grown there about 1836. For over thirty years the industry prospered and, by 1870, the number of factories had risen from twenty-one to three hundred and four. Rotations were discarded and crops of sugar beet were grown many years in succession on the same field. Beet sickness then appeared and, by 1876, it is said that twenty-four factories had closed down owing to repeated crop failures.

The trouble had been developing for some years. Schacht had observed the worm on roots of beet in 1859. During the 1870s, both in Germany and France, investigations showed this pest to be the cause of beet sickness. The worm was named after Schacht by Schmidt in 1871.

Our beet sugar industry is of much more recent origin. The Cantley Factory started in Norfolk in 1912, and in the East Midland Province factories started at Kelham in 1921, Colwick in 1924, Bardney in 1927 and at Brigg in 1928. The eelworm was first reported in this country on a sugar beet crop in the Eastern Province in 1934. By 1938, ninety-six fields were affected in three provinces.

The first record in the East Midland Province was in the Isle of Axholme (Lindsey) in 1936. It was on a small field and, in addition to sugar beet, mangolds and swedes were also attacked. Sugar beet had only been grown on part of the field once before, namely, in 1935; red beet had been frequently grown. The next infested field was at Kirkby-cum-Osgodby (Lindsey) in 1938, and in the same year the Loughborough Sewage Farm (Leics) was found to be infested. In 1939 a large sewage farm at Egginton (Derbyshire) had about eighty-seven acres infested.

With the increased spread of the eelworm in the eastern counties, it was thought desirable to try to control it by making certain provisions in an Order under the Destructive Insects and Pests Act. Accordingly, in 1943, the Sugar Beet Eelworm Order was issued. This was amended in 1950 and again in 1952.

By 1952 we know that in the East Midlands twenty-nine fields were infested, together with fields on seven sewage farms (the latter fall rather into a special class).

How this species came to be introduced to this country is not known, but American workers claim it was introduced to the U.S.A. by dirt adhering to the imported seed. This may also well have been its method of introduction to Britain.

It is unfortunate that the pest has invaded the Isle of Axholme, as this is an area where red beet is grown intensively and where so much of it is grown on unfenced strips in open fields. This means that, under the Order, all strips extending to some proper boundary have to be scheduled once any strip is found to be infested. A serious factor with this pest is the wide range of its host plants. In addition to sugar beet,

red beet, fodder beet and mangolds, all the cruciferous crops are attacked.

An owner of any field scheduled as infested is not allowed to grow any of these crops for three growing seasons, after which a licence can be granted to grow the next susceptible crop. If the field is sick or heavily infested, an initial rest of five years is necessary, when the field has to be examined for the cyst content of the soil. Once the population has been sufficiently reduced, the land ranks as ordinary infested land and is placed on a four-course rotation.

The distribution of the pest in the province is as follows :

County	Farm Fields	Sewage Farms
Lincolnshire (Lindsey) ..	26	0
Lincolnshire (Kesteven)	2	1
Nottinghamshire ..	0	0
Derbyshire	1	1
Leicestershire	0	1
Rutland	0	1
Northamptonshire ..	0	3

Of the fields in Lindsey, all but one lie in the south of the Isle of Axholme. Except for this area, in which probably more infested fields will be found, there is considerable hope that the spread of the eelworms will be virtually stopped. In all the known cases the trouble has been caused by too intensive cropping of susceptible crops, especially of the beet family.

CEREAL ROOT EELWORM (*Heterodera major* (O. Schmidt))

This eelworm was first recorded in Britain by Theobald on oats in Lincolnshire in 1908. By the late 1930s when Potato Root eelworm was spreading and Sugar Beet eelworm was appearing in several places, one began to wonder if this pest, too, was already widespread.

In 1939 we solicited the help of a well-known beet sugar factory in order to make a preliminary survey. The fieldmen sampled fields on eighty farms in the factory area, at the rate of one field per farm. These samples were examined for lemon-shaped cysts, and small numbers were found in twelve fields more or less evenly scattered over the factory area. Of these, ten were on the Wolds and two on the Carrs. These cysts were, in all probability, those of Cereal Root eelworm. None was ever found on the roots of the plants in spite of careful search during several succeeding years. The inquiry merely showed that while there was no immediate danger of trouble, there was in Lincolnshire a potential threat. Moreover, we were then embarking on a great drive for more cereals.

In 1949, three farms in the north of Lindsey had sickly oat crops. Cysts were found on all these and they appeared to be definitely harming the crops. On one of the farms which had practiced self-sufficiency for the cattle, oats were a prominent crop and several fields were affected. In 1950, three more fields of oats had cysts on the roots of sickly plants : two of these were in Lindsey and one in Kesteven. The eelworm was not necessarily the cause of the failure, but it was present.

In 1951, fields on six farms in the Chesterfield district of Derbyshire were reported as being infested : in this district oats are a major cereal crop. There were also abundant cysts on oat crops in three more places in north Kesteven.

In 1952, fields on eleven more farms were found with cysts on the roots. Four of these were in north Kesteven, one in the extreme south of Derbyshire, two in the Chesterfield district, three in Lindsey, and one in the north of Nottinghamshire. On the Nottinghamshire farm, and on one of the Lindsey farms the crop was wheat. In the remaining cases the cysts were on oats.

In the majority of the total of twenty-six sites in the province it is not suggested that the eelworm was responsible for much damage. Stem eelworm (*Anguillulina dipsaci*) as well as other pests often accompanied it, Cereal Root eelworms were present in large numbers.

In 1951, the cyst content of the soil on five fields on four of the affected farms in the Chesterfield area was obtained. Separate samples were taken from an area where the oats looked well, and from a part where they were sickly. The counts were low but, on the average, there were 2.8 cysts per 25 grammes of soil on the good part and 5.2 cysts per 25 grammes on the bad part. In one case the counts were equal, and in one there were more cysts on the good part than on the bad. This would seem to indicate that although this pest was present it was not the main cause of the trouble.

This species is probably indigenous. Much of our farmland must have been cropped, since the foundation of the manorial system, on a three-course rotation of wheat, spring corn and fallow, so why should the eelworm be more in evidence today ? Undoubtedly, a greater search is made nowadays for pests—but might it be that our new varieties are more susceptible to eelworms ? All we can say is that there are now twenty-six sites scattered about the northern part of this province where Cereal Root eelworm has been present on crops. We must hope that it is merely a passing phase and that it will not follow the way of the Potato Root eelworm and the Sugar Beet eelworm.

Incidentally, all cereals as well as grasses can be attacked, but oats appear to suffer most in the various countries where the eelworm is an acknowledged pest.

Of the Pea Root eelworm (*Heterodera göttingiana* Liebscher), we have but two records, one in Kesteven and one in Nottinghamshire ; and of the Cabbage Root eelworm (*Heterodera cruciferae* Franklin) we have had only one field record in the north of Lindsey.

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